

TOBACCO DISEASES



W. D. VALLEAU, E. M. JOHNSON
and STEPHEN DIACHUN

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CONTENTS

	Page		Page
CAUSES OF TOBACCO DISEASES	3	False Broomrape	32
SOIL IN RELATION TO TOBACCO DISEASES	4	Dodder	33
Soil Fertility	4	LEAF DISEASES	33
Soil Reaction	4	Angular Leaf-Spot and Wildfire	33
Organic Matter	5	Frogeye and Greenspot	38
Crop Rotation	5	Leaf Scald	40
PHYSIOLOGICAL DISEASES ..	6	Weather Fleck	41
Nitrogen Deficiency	6	VIRUS DISEASES	42
Phosphorus Deficiency	7	Mosaic	42
Potassium Deficiency	8	Mosaic-Resistant Varieties	46
Calcium Deficiency	9	Plantago Virus	48
Manganese Toxicity	9	Ring-Spot	48
2, 4-D Injury	9	Streak	50
Frenching	11	Curly Top	52
PLANT-BED DISEASES	14	Other Virus Diseases	52
Blue Mold	14	STALK DISEASES	52
Fertilizer Injury	17	Fusarium Wilt or Yellows	52
Blackleg	18	Sore-Shin	54
Cold Injury	18	Black Shank	55
Blotch or Scab	20	Stalk-Rot or Hollow Stalk	59
Anthrachnose	20	Bacterial Black Stalk	60
Damping Off	21	LIGHTNING INJURY	60
ROOT DISEASES	22	HOUSEBURN	61
Black Root-Rot	22	RECOMMENDATIONS FOR CONTROL OF TOBACCO DISEASES IN KENTUCKY..	65
Brown or Nematode Root-Rot ..	26	Seed	65
Manure and Cover-Crop Toxicity	27	Plant Beds	65
Root Knot	27	Chewing and Smoking While Handling Plants	67
Pythium Soft Rot	28	Field Practices	67
Club-Root	28	Curing	68
Broomrape	29		

(To simplify information in this publication, trade names of some products are used. No endorsement is intended, nor is criticism implied of similar products not named.)

Tobacco Diseases

By W. D. VALLEAU, E. M. JOHNSON, and STEPHEN DIACHUN

Department of Plant Pathology

CAUSES OF TOBACCO DISEASES

Tobacco diseases may be considered as abnormalities of the plant that cause reduced quality or quantity of the commercial product. This definition includes various malnutritional diseases caused by soil deficiencies, injuries caused by fungi, bacteria, roundworms or nematodes, parasitic flowering plants such as broomrape, virus diseases, and "burning" of wilted plants. Insect injuries might be included, but are not discussed in this publication. If it is kept in mind that diseases may be produced by one or a combination of these causes, it will be easier to understand the reasons for the various control measures recommended and the changes which are made from time to time in these recommendations as new facts are discovered. A short description of the organisms that cause disease may interest those unacquainted with the lower forms of life.

Fungi are plants of a low order, such as the mushrooms and various molds that grow in damp places. A common fungus familiar to all is the green mold sometimes seen on canned fruit. Certain forms of fungi are common causes of plant disease. They subsist either on the living plant cells, as rust of wheat and other cereals, and mildews of various crops, or by killing the plant cells and living on the dead tissues, as in fruit rots or the black root-rot of tobacco.

Bacteria are sometimes classed as one of the groups of fungi. They are single-celled plants. The individual cells are visible only with a microscope. A mass of them, however, may be readily visible to the unaided eye.

Virus diseases are caused by organisms so small that the individual particles cannot be seen with an ordinary microscope. However, their images can be seen and the particles photographed with an electron microscope. The virus content of the plant increases rapidly following infection but the exact method of reproduction is not known. The viruses are characterized by being able to multiply only in living cells.

Nematodes are roundworms that can sometimes be seen with the unaided eye. They are similar to the hookworm of the human and to roundworms causing trouble in many animals.

Parasitic flowering plants are plants such as broomrape, dodder, and mistletoe that have become adapted to obtaining food materials or nutrients directly from some other living plant instead of from the soil.

Physiological diseases, or those not caused by disease-producing organisms, often result from a lack of sufficient available nutrients or an excess of one or more of the compounds necessary for plant growth. The quantity of available nutrients in the soil is determined in part by the total content of the necessary minerals in the soil and the degree to which the land has been cropped and manured.

For example, alfalfa removed for hay reduces the available mineral content of the soil rapidly, because of heavy yields produced, unless part of the nutrients is returned in the manure from feeding the crop. Legumes or legume-grass mixtures, if left on the land or turned under, tend to accumulate available nutrients. Close pasturing of grassland may reduce available nutrients, especially if the droppings are deposited in restricted areas, such as shady places in the field. Therefore, the fact that a bluegrass sod has not been plowed for many years is no assurance that it will make good tobacco land.

SOIL IN RELATION TO TOBACCO DISEASES

Growers are well aware of the desirability of selecting the most favorable soil for tobacco. The reasons for the selection or rejection of certain soils for tobacco are not always well understood but are usually arrived at by experience. The relation of soil to diseases will be discussed more fully under the specific diseases but reference is made here to a few of the more obvious relations.

Soil Fertility

Tobacco makes an enormous growth in a very short period; consequently, a high level of available nitrogen, phosphorous, and potassium should be present in the soil when the crop is set. Lack of enough of any one of these nutrients results in slow growth, late maturity, excessive firing, or may aggravate leaf-spot diseases of one kind or another.

Soil Reaction

Soil reaction or the degree of its acidity or alkalinity is an important factor. Experience has demonstrated that tobacco thrives best in moderately acid soil. The use of too much lime often seems to be a contributing cause of freching. The black shank organism seems to persist much longer in limed soils than in acid soils. Certain minor elements like manganese are, in minute quantities, necessary for plant

growth. In strongly acid soils these minor elements often are very soluble, and the amounts present may be enough to cause slow growth and leaf spotting. On such soil an application of ground limestone may prove beneficial to tobacco.

Organic Matter

Organic matter, if well rotted and mixed with the soil, is generally beneficial to tobacco because it tends to increase fertility and reduce leaf-spot diseases. Manure is generally beneficial both to burley and to dark tobacco, but where successive crops of tobacco are grown in manured soil, black root-rot is almost certain to develop, unless a highly resistant variety is grown. Strawy manure and cover crops, which do not decay before tobacco is set, sometimes cause root injury as a result of the production of temporary toxins. Leaf mold, turned under in newly cleared land, sometimes results in frencched tobacco if it is the first crop.

Crop Rotation

The grower should profit by experience and give careful study to selecting the crop to precede tobacco in a rotation. In spite of extensive studies on rotation for tobacco it is not possible at present to recommend any rotation as being best for tobacco except that a well-fertilized, lightly pastured grass-legume sod nearly always produces excellent tobacco. The burley industry was developed largely on the basis of a long-time sod-tobacco rotation, and this is still good if the sod has not been over-pastured and if the land has not become too heavily infested with meadow nematodes, small round worms that cause brown root-rot. There are many partial failures when tobacco follows old bluegrass sod, caused either by meadow nematodes or reduced fertility, particularly low available potash, resulting from overgrazing. Tobacco may grow slowly after corn, soybeans, timothy, orchardgrass, and some of the meadow and pasture legumes, particularly in a season that is wet during or immediately following setting. Alfalfa or other legumes cut for hay cause depletion of nutrients, particularly potash, and result in poor quality tobacco if it follows the legumes, unless the soil is well fertilized. Weeds make an excellent preparation for tobacco, presumably because those weeds develop best that are highly resistant to pathogenic organisms such as meadow nematodes, and consequently leave the soil relatively free from injurious organisms. A rotation that is all too commonly used in Kentucky is continuous tobacco with a cover crop of a small grain and hairy vetch. In fields that have been in this rotation or in a tobacco-small grain rotation for years, meadow nematodes are found in extremely small numbers, if at all, but the soil gradually becomes compacted,

poorly aerated, and highly acid, increasing root troubles and manganese toxicity. With the rapid spread of black shank a rotation is to be preferred over continuous tobacco. If a few black shank plants in a field one year are disregarded they may result in heavy loss the next year. Rotation will greatly reduce the chance of appreciable loss.

Physical Condition of Soil

Good physical condition of the soil is desirable, especially good surface and under drainage. Tobacco often frenches on soil too wet, or if water stands long about the plants it may cause them to wilt, turn yellow, and finally die. On hard, poorly aerated soil tobacco grows slowly and produces inferior leaf. Loose, open soil such as results from plowing under a good sod is most likely to make rapid-growing, high-quality tobacco, if the necessary nutrients are available.

PHYSIOLOGICAL DISEASES

Physiological diseases may be caused by either temporary or extended lack or excess of certain elements in the soil. Nitrogen, phosphorus, and potassium are the three elements most likely to be deficient in Kentucky soils. Magnesium deficiency, which causes sand drown, is rare. Growth of large, well-formed leaves of high quality largely depends on the proper nourishment of the plant. Therefore much attention should be paid to soil improvement and to the kind and amount of fertilizer used.

Nitrogen Deficiency

Deficiency of nitrogen is indicated by slow-growing, light-green plants. Soils low in organic matter, if thoroughly wet, may run together to a point where nitrification stops and the tobacco turns yellow and fails to make further growth. But all yellowing is not caused by a lack of nitrogen. On very hot, bright days the lower leaves of field plants may lose chlorophyll and turn yellowish, only to regain color during cloudy periods. Recently set plants may start growth, then turn yellow because of loss of roots from soil toxicity when the nitrogen supply is adequate. At present many tobacco growers are using far too much nitrogen, both in plant beds and in the field, so additional nitrogen should not be applied unless one is certain of nitrogen deficiency.

Prevention: A heavy grass-legume sod turned under plus 100 to 200 pounds of ammonium nitrate will usually furnish sufficient nitro-

¹ For recommendations on fertilizing soil for tobacco see your county agricultural extension agent.

gen. Proper applications of manure or fertilizer high in nitrogen prevent nitrogen starvation. Nitrogen fertilizers may be applied as a side-dressing after tobacco is set. An oversupply causes plants to remain green long after topping.

Phosphorus Deficiency

Slow-growing, stunted, dark-green, late maturing plants usually indicate lack of phosphorus, but under certain conditions other symptoms may develop. Tobacco plants from a well-fertilized bed set in soil very deficient in phosphorous may turn a yellowish green in the older leaves especially at the tips and suddenly develop numerous dead spots in these leaves during the first few weeks after setting (Fig. 1).



Fig. 1.—Phosphorus starvation in burley tobacco. This type of spotting occurs soon after growth begins on plants which were well-nourished in the plant bed but set in a field having little available phosphorus. When the roots penetrate a larger volume of soil, spots are no longer produced.

Also plants set in soil with adequate phosphorus may develop temporary phosphorous deficiency if the new roots are killed shortly after growth starts, as a result, perhaps, of cover-crop toxicity. As the roots spread out in the soil and the plants adjust their growth to the available phosphorus the later leaves are dark green.

Prevention: Unless a field to be used for tobacco is known to have plenty of available phosphorus, a phosphate fertilizer or a mixed fer-

tilizer high in phosphorus should be liberally applied. Manure is low in phosphorus and cannot be relied upon to correct phosphorus deficiency. A soil test for phosphorus will indicate fairly well the amount of phosphate that should be added.

Potassium Deficiency

Although Kentucky soils generally are high in total potassium, tobacco frequently shows signs of potash starvation. This is because the rate at which potash becomes available in the soil is not great enough to meet the needs of the tobacco crop which require a large amount in a short time. Potash starvation is often more obvious on heavily limed than on unlimed soil. For example, tobacco grown near an old limestone road, where limestone dust has been settling for many years, often shows marked potash starvation whereas that at a distance from the road may show little or none.

Potash starvation is readily recognized in tobacco. A mild deficiency may cause merely the rolling of the slightly yellowed edges of the leaves downward or bronze-yellow blotches on the leaves, especially on the tips of the upper leaves (Fig. 2). In more severe cases the leaves are curled downward at the edges or are "rimbound" and the



Fig. 2.— A mild case of potassium starvation of burley tobacco. Dead spots are just developing on the two leaves at the left. More severe starvation results in rim firing and in death of leaf tips.

tips and edges may die and turn dark. The portions of the blade of the leaf between the larger veins are curved upward as if the veins were too short. The leaf usually is light green with yellowish blotches, and the whole plant may have a distinct bronze tinge. Where there is not enough potash but plenty of nitrogen the tobacco is red or dark brown when cured but where there is enough available potash, phosphorus, and nitrogen, both the yield and quality of the tobacco are high.

Prevention: Potassium starvation may be prevented by applying barnyard manure, potash fertilizers, or liberal quantities of mixed fertilizers that contain a high percentage of potash. Land known to be low in available potash will require about 1500 pounds per acre of 5-10-10 fertilizer to meet the potash requirement. A soil test will indicate the level of available potash.

Calcium Deficiency

Calcium is usually available in sufficient quantities in Kentucky soils to produce a normal crop of tobacco. However, in protracted dry periods when burley tobacco is commencing to bloom and produce suckers, the tips of the calyx lobes of the flowers may turn brown and die and the edges of the small leaves of the suckers may be necrotic resulting in irregularly shaped sucker leaves. The condition appears to be caused by improper utilization of calcium by the plant.

Manganese Toxicity

Tobacco set in very acid soil (pH below 5.0) is likely to develop manganese toxicity (Fig. 3). The plants grow slowly following setting, turn light green or yellowish between the larger veins, and gradually develop numerous dead spots, particularly in the older leaves. There is something in common between the appearance of manganese toxicity and the spotting caused by phosphorus starvation, but the conditions appear to be distinct. A similar condition may develop in the winter cover crop that follows tobacco. Sometimes plants recover and develop a normal green color in later leaves, possibly because the soil becomes less acid following decomposition of the cover crop. The addition of lime to the soil prevents the trouble from occurring in subsequent crops.

2, 4-D Injury

Injury from 2, 4-D to tobacco is quite common in tobacco beds and fields. In beds it usually results from the use of a pressure sprayer that has been used some time in the past years for 2, 4-D or from 2,4-D drifting onto the cotton cover following spraying of a nearby pas-



Fig. 3.— Manganese toxicity occurs where tobacco has been grown year after year in the same field until the soil has become too acid.

ture. In the field injury is frequently caused by spray drifting across a tobacco field, or the ester form volatilizing and drifting across a tobacco field, or by insects from a 2,4-D sprayed area alighting on a tobacco plant.

The symptoms in the plant bed are variable. When small plants are sprayed with extremely small amounts of 2, 4-D the young leaves may grow together, giving a vase or wine glass effect (Fig. 4). Older plants in the bed may show the typical 2, 4-D injury to leaves, illustrated in Fig. 5.

Field plants are affected in two ways. The leaves may show the typical 2, 4-D injury. If the amount of 2, 4-D added has not been very minute a gall-like swelling at the crown may develop that breaks out on one side with the appearance of numerous root tips. A minute amount of 2, 4-D in setter water may cause leaf symptoms, but it also kills the small roots. New roots that develop may be flat and curved. Some plants may die while others gradually recover.

Spray equipment can sometimes be freed of 2, 4-D if all parts are washed thoroughly in strong ammonia water but it is best never to use spray equipment for spraying tobacco if it has ever been used for 2, 4-D. The salts of 2, 4-D are safer to use as weed killers near tobacco fields than the esters, but in either case spraying should be done at a time when the spray will not drift toward the tobacco.

Frenching

Frenching, or wet-weather french, though sometimes confused with mosaic of tobacco, is a distinct disease. Newly frenched plants are nearly white in the growing point (Fig 7). The frenched leaves are narrowed and drawn and the tips sometimes bend sharply downward forming a cup of the underside of the leaf. Later, affected leaves may turn dark green. In severe cases terminal growth ceases, suckers develop but grow slowly and the new leaves are reduced to narrow straps made up mostly of the midvein. The number of leaves greatly increases, sometimes to hundreds on a plant.

Frenching develops under a variety of conditions. It is more prevalent in seasons of abundant rainfall and nearly absent during protracted dry periods. If the soil moisture content is reduced before numerous lateral buds start growth, the plants may recover completely.

Frenching occurs in soil that is near the neutral point (about pH 6 or above),² but plants growing in soil of the most desirable



Fig. 4.— 2,4-D when applied to very young plants causes formation of a cup-like structure.

² The term pH refers to acidity or alkalinity. A neutral soil has a pH of 7. Figures smaller than 7 indicate degrees of acidity; figures larger than 7, degrees of alkalinity. The smaller the figures below 7, the stronger the acidity. The soils of

(Continued on next page)



Fig. 5.— Typical 2,4-D injury on leaves of burley tobacco

acidity for tobacco (about pH 5.6 or below) are not likely to french. Studies of the disease in the greenhouse have shown that frenching sometimes is associated with a lack of available nitrogen in the soil, but at other times it seems to occur in the presence of available nitrogen when some other nutrient, as phosphorus, is deficient. Frenched plants sent in for determination of the disease are usually high in nitrates.

In Kentucky frenching is frequently found on soil that has been limed, either intentionally or by limestone dust blowing or washing from a road onto the neighboring field. In fertile soil, liming may not

(Footnote continued from preceding page)

the Bluegrass region are about pH 5.6 except in the hilly area where alfalfa can be grown without liming. Here the pH is about 7. The soils of the rest of the state are slightly more acid.

induce frenching in the growing crop but it may appear after topping, in the suckers. Frenching and a low level of available potash are frequently associated, but there is little evidence that there is a casual relation between low available potash and frenching.

Studies made at the U.S. Department of Agriculture, by Steinberg, indicate that frenching can be caused by a toxin formed by *Bacillus cereus*, a saprophyte common in all soils that grows on the surface of roots. The bacteria increase 60 to 200 percent when field plants french. Isoleucine, an amino acid, increases in frenched leaves, due to the action of the toxin, and in turn causes the visual symptoms characteristic of frenching.

Prevention: Frenching can always be prevented in the greenhouse by sufficient applications of the necessary fertilizing elements. In the field, prevention is not so simple because of the variety of conditions under which the disease occurs. Addition of rotted manure or other organic matter that decays readily, proper soil drainage, and application of fertilizers recommended for tobacco are beneficial in soil known to produce the disease. In the unusually wet season of 1955 frenching was rare in sections where before the use of adequate mixed



Fig. 6.— Randonx T, sometimes used for control of weeds in corn, has this effect on tobacco following exposure to its fumes.

**Fig. 7.— Frenching
of burley tobacco.**



fertilizer the disease was common. If a liming material is to be used on tobacco land, apply a small quantity following the tobacco crop rather than immediately preceding it. Fertilizers containing considerable quantities of ground limestone as a filler should not be used for tobacco.

PLANT BED DISEASES

Under this heading only those diseases that are confined to the plant bed are discussed. Angular leaf-spot, wildfire, mosaic, and black root-rot affect plants both in the bed and in the field, and are discussed later.

Blue Mold

Following 1937, when blue mold caused extensive damage to plant beds in Kentucky, it appeared in some second-year beds and slowly spread to new beds, causing little damage. By 1944 it seemed to have disappeared completely from the state. Spores were again blown in in 1945, when another severe outbreak occurred. Carryover in second-year beds caused a moderately severe outbreak in 1946 and very mild outbreaks in 1947 and 1948. By 1951 the disease had again almost completely disappeared from the state. From past experience it appears that the disease if present will be generally severe in Kentucky

only in years when plant beds are exceptionally early. Other years it will cause injury only in beds that are shaded or are late.

The disease is caused by a fungus³ that is common on wild tobacco, *Nicotiana repanda*, in Texas. It is probable that spores of the fungus blew from Texas to Florida in 1921, where it failed to become established—probably because of the active campaign directed toward the destruction of all affected beds and toward the use of new bed sites in 1922. In 1931 when spores again blew in and no effort was made to eradicate it, it became firmly established in the recently developed flue-cured tobacco area of Georgia.

The fungus overwinters in the Georgia-Florida area on volunteer tobacco and probably as oöspores in beds used a second time, and farther north in plant beds used the previous year. The disease usually appears about 2 weeks earlier in old beds than in new ones. It produces heavy-walled resting spores, or seed-like bodies, in the dying or dead leaves. These are capable of remaining in the soil at least a year and attacking the next crop of plants if the same site is used again for tobacco plants. After penetrating the leaves the fungus produces grape-like clusters of spores on the undersides of the leaves (Figs. 8, 9). These can be seen in the early morning as a bluish moldy

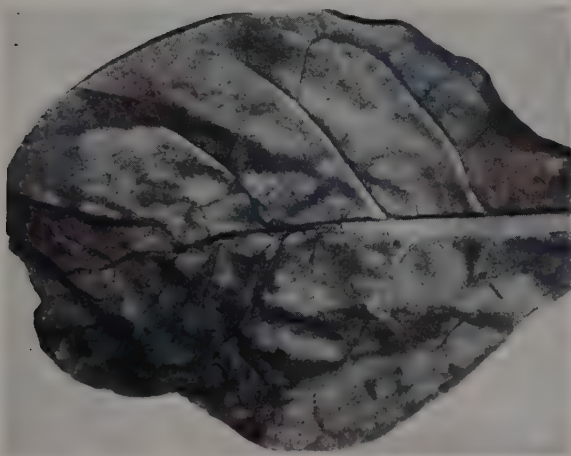
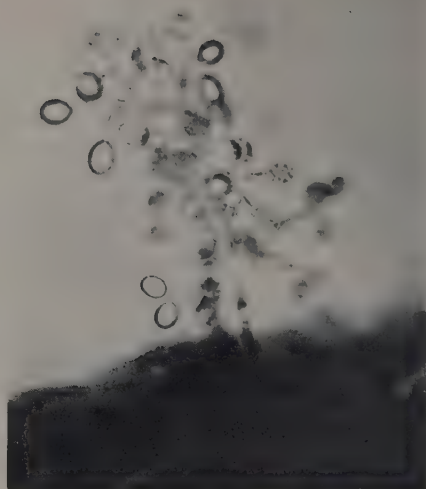


Fig. 8.— Blue mold showing spore masses on the under side of a leaf. These spores, when blown about, cause new outbreaks in the same bed and in beds at a distance.

³ *Peronospora tabacina*.

Fig. 9.— Sporangioophores of the blue-mold fungus, borne on the underside of a leaf, showing sporangia or spores.



growth. These spores, carried by winds for long distances, rapidly spread the disease.

If the weather is dry, the first sign of the disease is likely to be yellowing and stunting of a group of half-grown plants.⁴ These symptoms are similar to those of nitrogen starvation. No other symptoms will likely appear unless the weather becomes wet, when infection may spread to other parts of the bed causing yellow leaf spots or large scalded areas on the leaves of plants about ready to set. It is sometimes difficult to find spore masses on the yellow to brown spots and flecks that sometimes occur at about setting time. Sometimes, in wet weather when the plants are tender, the leaves rot, making a stinking mass of plant material. If infection is mild, the plants may be set in the field without danger of dying, but if it is severe so that the stems of the plants are darkened near the ground line, they are almost certain to die if set in the field. If, however, the plants are given nitrate fertilizer and allowed to recover for about 10 days, they are satisfactory for setting.

Prevention and control: Since there have been only three moderately serious outbreaks of blue mold in Kentucky (1937, 1945, 1946) during the 32 years the disease has been present in Eastern United

⁴ Blue mold rarely appears in the plant bed in Kentucky until setting time or a few days before. Outbreaks which begin in the bed during wet, cool periods when the plants are about one-fourth grown and kill many plants, are commonly attributed to blue mold but are usually wildfire or, in less severe cases, angular leafspot.

States, control measures are usually not necessary. It is good practice to locate beds in the open where they get no shade. This may delay an outbreak a week or two. Chemicals on the market such as ferbam and zineb⁵ have been found to be very effective in preventing the disease or slowing it down if it has already started. These materials can be used effectively either as a dust or spray. Directions for treatment can be obtained from county agents or from the Experiment Station at Lexington. A supply of one of them should be on hand during the plant-bed season in case an outbreak of blue mold occurs. Zineb may also be used to control leaf spot diseases of tomato.

There is good reason to believe that if tobacco growers in northern Florida and Georgia would destroy beds after setting is complete, not allow any field plants to live after harvest, and use new plant bed sites the next winter, or beds that have been sowed to a summer legume after setting, and plowed under in the fall, blue mold would be eradicated in that area and would gradually disappear farther north, as the fungus does not seem to be able to perpetuate itself by oöspores alone.

Fertilizer Injury

If weather is dry in late April and early May, small tobacco plants $\frac{1}{4}$ -to 2 inches across may turn yellow and die or, when touched, break off at the surface of the ground. Usually the area in the bed where this occurs has a white coating over the surface soil particles made up of salts carried to the surface by evaporating water. These salts injure the small roots of the plants and prevent growth of new roots from the crown. Just below the crown the tap root may be scalded and broken readily if touched. Such a condition is usually brought about by the grower applying too much fertilizer to the surface of the bed before sowing, or from excess of potash salts following burning a bed with wood. It is common practice to apply an 80-pound sack, and sometimes two sacks, of fertilizer on 100 feet of bed 12 feet wide. If the season is wet continuously no harm will result, but if the season is dry, even for short periods, plants in large areas of the bed may die. Similar injury sometimes follows the use of calcium cyanamide for weed control. A contributing factor to injury appears to result from too heavy burning in spots in the bed.

Prevention and control: Do not use over 25 pounds of a complete fertilizer such as 4-16-4 on a steamed bed 100 feet long and 12 feet

⁵ These materials are sold under various trade names. The name and amount of the active ingredient is stated on package labels. The active ingredient in ferbam is ferric dimethyl dithiocarbamate; in zineb it is zinc ethylene bisdithiocarbamate.

wide. On a burned bed, where potash is abundant in the ash, use about 40 pounds of 20 percent superphosphate and apply nitrogen if necessary. If too much fertilizer has been used, or if the bed has been treated with cyanamide, and the plants are yellowing in a dry period, water them heavily to dilute the salts and carry them into the soil.

Fertilizer injury may be completely prevented if a bed is sowed to soybeans following setting and the soybeans fertilized. The next spring sow the beds with a seeder or mix the seed with superphosphate.

Cottonseed meal, tankage, or chicken manure is sometimes used as a nitrogen fertilizer on tobacco beds after the plants are up, but in several cases observed each of these caused the plants to yellow and sometimes decay. Injurious molds sometimes develop where the cottonseed meal falls on the leaves. Nitrate of soda and ammonium nitrate, if properly applied, are much more satisfactory sources of nitrogen where immediate results are wanted.

Blackleg

This disease occurs in the plant bed during wet periods when the plants are about ready to be set. It is a bacterial soft rot attacking leaves that touch the ground and spreading from them into the soft, tender stalk. The stalk may rot off completely, or if it has become somewhat hard the rot may spread up one side, splitting it open. The rotted areas usually turn black, hence the name (Fig. 10). Frequently the plants in an area up to 3 feet in diameter are destroyed. Slightly affected plants when set in the field grow normally if set in rather dry soil, but if the setting season is wet it is not advisable to use plants from an affected bed as repeated resetting may not give a satisfactory stand. If diseased plants are kept over night for setting the following day, all the plants may be a slimy rotten mass. The disease is caused by *Erwinia aroideae*, one of the group of soft-rot bacteria carried by certain insects. The method of entrance into the bed is not known, but it may be by insects. The disease is rarely seen in beds treated with bluestone-lime mixture.

Cold Injury

This trouble often appears on plants in the bed following windy cold nights, particularly around tears in the cotton. It has become more common the past few years because of the use of thinner cotton. The bud leaves as they develop are white, presumably because of injury to the chloroplasts; and the partially developed leaves appear constricted and white along the edges of the distal portion (Fig. 11). With warm weather the affected plants recover quickly and grow

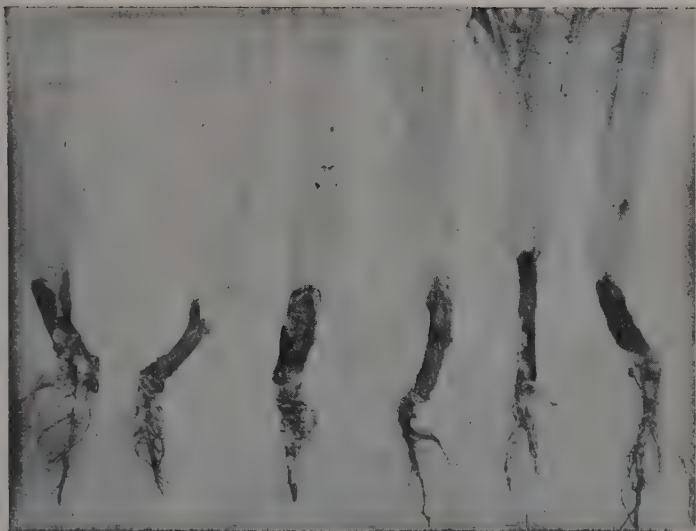


Fig. 10.— Blackleg of burley tobacco occurs in the plant bed as a soft rot, when the plants are about ready to set.



Fig. 11.— Cold injury to burley tobacco plants in the plant bed, following a cold, windy night. The same type of injury occurs on dark tobacco.

normally except that the affected leaves do not recover completely and appear mottled, with somewhat the appearance of mild mosaic.

Blotch or Scab⁶

This disease is characterized by olive-brown blotches on the upper leaf surfaces and stems of seedlings (Fig. 12A). It has been observed in Kentucky only on light-colored seedlings starved for nitrogen. It is



Fig. 12.— (A) Scab is common in plant beds. It occurs almost entirely on leaves which are chlorotic or yellowish. The fungus appears to be growing on the leaf surface. (B) Anthracnose on a leaf of burley.

particularly prevalent in wet seasons on plants affected by black root-rot. Where conditions which bring about susceptibility of the plants are corrected, as by the addition of nitrate, the disease is of no consequence.

Anthracnose

In 1935, a leaf-spot was abundant in burley and dark tobacco in the Experiment Station beds which had been flooded several times (Fig. 12B). From these spots an anthracnose fungus (*Colletotrichum*

⁶ Caused by the fungus, *Septomyxa affinis*.

destructivum) was isolated and found by infection studies to be capable of causing similar spots. This fungus is quite common on clovers and alfalfa in Kentucky. The flood water had swept across a pasture in which several species of legumes were growing. The disease has recently become fairly common and sometimes injurious to plants in the bed and sometimes to recently set plants in the field, but field plants usually recover with little or no injury. The fungus is usually washed into the bed by water flowing over it. It could also be introduced by a person walking through a wet pasture and then across a bed. Spring-plowed beds could be infected from pasture plants turned under unless the bed is treated with methyl bromide or other material that could kill it. Treating plants with ferbam or zineb as for blue mold will usually control the disease.

Damping-Off

A common and destructive plant bed disease in the tropics is damping-off caused by species of *Pythium*. It has been extremely rare

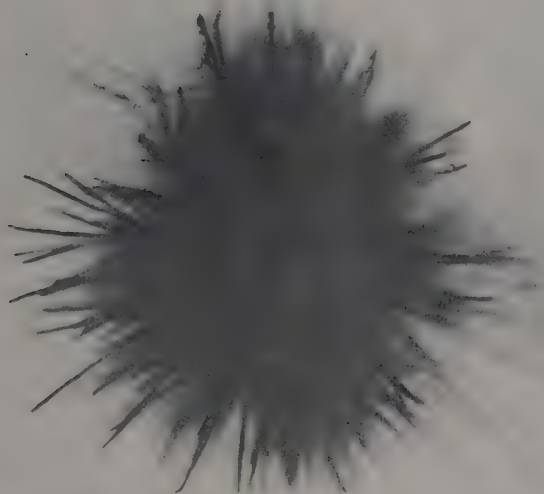


Fig. 13.—An acervulus or fruiting body of the anthracnose fungus, showing the long black setae amongst which the spores (upper left) are borne.

in Kentucky and has not previously been mentioned in earlier issues of this publication. In 1962 it appeared in numerous plant beds in Kentucky and southern Indiana. It appeared as a rot of seedlings,

with leaves about 2 or 3 inches long, commencing at the ground line and spreading upward finally killing a group of plants. The plants give the appearance of having been scalded (Fig. 14). The dead leaves lie on the soil surface. The disease appeared first about May 15 following 3 days with temperatures of about 90°F. This hot weath-



Fig. 14.— Damping-off occurred in 1962 during a humid period when the day temperatures were above 90°F. It is a rare disease in Kentucky.

er continued for 10 days during which time numerous reports and specimens of damping-off were received. Bluestone-lime, ferbam or zineb will give control. Removing the cotton for a few hours during the day will dry the soil surface and may prevent further spread of the disease.

ROOT DISEASES

Black Root-Rot

The black root-rot organism⁷ attacks the tobacco roots either in the plant bed or the field, rotting them and eventually turning them black (Fig. 15). It may be particularly severe where tobacco is grown repeatedly in the same soil, or in plant beds where the same site is

⁷ *Thielaviopsis basicola*.

used several times without thorough treatment. Injury in the bed may be so slight that diagnosis is difficult. In severe infestations the disease is recognized by slow growth of the plants and yellowing of leaves where there is no moisture or nutrient deficiency, and by the presence of dead, blackened roots.

It is likely to be present in plant beds in areas where the practice is to manure and use the same plant bed year after year but only when susceptible varieties are grown. Satisfactory plants usually are grown in these beds because steaming sterilizes the soil to a sufficient depth to permit the plants to develop. However, many of the roots penetrate the infested layer of soil and the disease may thus be carried to the field. The common practice of using a new plant-bed site each year is a means of avoiding black root-rot. Steaming permanent plant beds only enough to control weeds, has not proved effective in freeing them from black root-rot. Unless steaming is thorough it should not be relied upon to sterilize infested soil. It is particularly necessary to change the plant-bed site frequently when susceptible varieties are grown as in the dark tobacco areas of western Kentucky. Black root-rot resistant varieties such as Ky 16 and Ky 41A have been grown satisfactorily in heavily infested plant beds



Fig. 15.— Black root-rot of burley tobacco. A healthy root of a root-rot resistant strain and the root of a susceptible variety grown in the next row. The short, stubby, black roots, with a few normal roots near the surface of the ground, are characteristic of a severe case of this disease.



Fig. 16.— Chlamydozoospores of the black-root-rot fungus on a tobacco root.

so that precautions in the plant bed do not seem to be necessary even if only moderately resistant varieties are used.

Black root-rot often is the cause of slow growth of dark tobacco in soil known to be in a high state of fertility, especially when liberal applications of manure have been made. In western Kentucky this organism does not become established so readily unless the land has been manured or limed and the organic matter content built up. On some of these soils infected plants from a diseased bed make as good growth as highly resistant plants of equal size from the same bed. Where limestone is to be used on tobacco land it should be applied following tobacco and in as small a quantity as will give the desired effect in growing legumes.

All the old dark tobacco varieties and the varieties that have been developed recently directly from them have proved highly susceptible to black root-rot in infested plant beds and all of them are injured if set in infested fields.

Now that resistant burley varieties are available, black root-rot is rarely seen in burley beds. Susceptible dark tobaccos are still generally grown and black root-rot may cause damage in burned beds used a second time. Steaming, treatment with methyl bromide, or the use of a new plant bed site each year will usually prevent loss from black root-rot in dark-tobacco beds. The development of root-rot

resistant dark tobaccos is progressively rapidly, and with the introduction of satisfactory varieties there should no longer be loss in the plant bed from black root-rot.

In the field, black root-rot rarely causes serious loss to burley tobacco because all of the varieties now grown have some resistance to the fungus. However, the degree of resistance varies from relatively low in Ky 16 and Burley 21 to high in the newer varieties as Ky 9, and Ky 12. Ky 16 and varieties with the same degree of resistance may be injured particularly when grown year after year in the same plot of ground. Whether the injury can all be attributed to black root-rot or whether it is a combination of poor aeration, due to the soil gradually losing texture, and toxicity of decaying organic matter is difficult to say. In well-aerated soils any of the resistant varieties do well.

Prevention and control: Use a variety resistant to black root-rot, if a satisfactory one can be obtained, whether the soil is infested or not, as it will reduce injury in an infested soil and prevent a clean soil from becoming infested. In the event that a resistant variety is not used the following precautions should be taken. Use a new bed site each year or steam a previously used bed at least 30 minutes, preferably 40 or treat it with methyl bromide. To prevent infestation of a field do not use plants from a diseased bed. If limestone has been used on the tobacco land, use a new bed each year. As manure in-



Fig. 17.—Two strains of burley tobacco resistant to black root-rot and, in the center, a variety of burley susceptible to the disease. All were set at the same time, in soil infested with the black root-rot fungus.

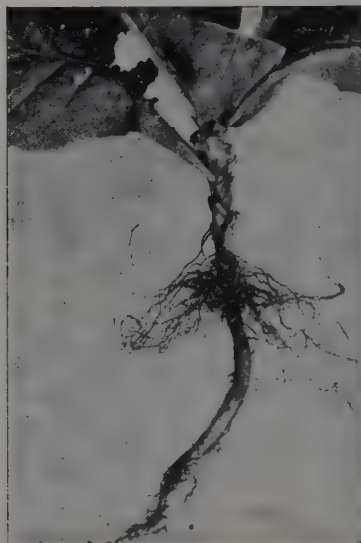
creases injury from black root-rot, tobacco should not be grown in successive years on heavily manured land unless a resistant variety is grown. When burley tobacco is grown continuously in a field with a cover crop of vetch and small grain, the variety should always be a resistant one and preferably a highly resistant one such as Ky 9 or Ky 12.

Brown or Nematode Root-Rot

Brown root-rot is a disease of field-set plants. It may occur after such sods as bluegrass, orchardgrass, or timothy, or after alfalfa, red clover, corn, and perhaps other crops. That the preceding crop itself, or its by-products, is not the direct cause of the trouble is proved by the fact that some of the best burley tobacco is grown following a virgin sod or in old bluegrass pastures that have rarely been cropped. If a heavily infested tobacco crop is followed the next season with tobacco, the second crop is not likely to have a severe attack of brown root-rot. Tobacco following weeds is usually unaffected.

Brown root-rot attacks the plants soon after they become established following transplanting. The rootlets begin to turn brown in spots and finally die, only to be replaced by new rootlets. The plants are likely to wilt in the middle of the day. Growth is slow. Finally roots are put out close to the surface of the ground and the plant commences growth (Fig. 18). This usually occurs in late July. If the soil is fertile a late but fairly satisfactory crop may result, but if the soil is infertile, the crop may be nearly a complete failure.

Fig. 18.—Brown root-rot of burley tobacco. Nearly the entire active root system has developed near the soil surface.



Brown root-rot is caused by meadow nematodes.⁸ These nearly microscopic roundworms when present in a field may be found in the roots of many grasses (including bluegrass, orchardgrass and timothy), in roots of most, if not all legumes, in corn, and in many weeds. The roots of ragweed appear to be almost free, while the roots of wild lettuce carry them through the winter in immense numbers. The common winter cover crops, wheat, rye, barley, and vetch, are all susceptible to the nematodes.

Roots of tobacco plants set in upturned roots of plants heavily invaded by nematodes become invaded soon after they begin to grow.

On a farm where brown root-rot has been known to occur, it is probably better to raise two or more tobacco crops in succession in the same field, rather than plow a new field and take a chance on the disease. In fields where tobacco is grown continuously, with a winter cover of vetch and a small grain, tobacco usually starts rapidly and shows no signs of brown root-rot.

Manure and Cover Crop Toxicity

Frequently specimens of tobacco with severe root-rot are received which have no sign of black root-rot or of infection by nematodes. These appear to be the result of toxicity from decaying organic matter. In fields where cover crops are turned under late, or for other reasons do not decompose early enough, or in fields where much strawy manure has been plowed under, tobacco starts slowly and the roots show extensive signs of injury. Early plowing so that the temporary toxic period is passed before tobacco is set will prevent this type of injury.

Root Knot

Root knot, caused by nematodes,⁹ or roundworms, is found occasionally in tobacco plantings in Kentucky. The tobacco roots and rootlets are enlarged at irregular intervals (Fig. 19) causing them to have a more or less beaded appearance. If the knots are broken open carefully, the small, white, spherical, female worm may be found in the knot. The disease probably occurs most commonly on tobacco growing on land previously used for a garden. Nematodes are frequently introduced into garden soil on tomato plants grown in the greenhouse or shipped from the South.

Control: Root knot is not serious in Kentucky and requires no special precautionary measures except in fields where diseased plants of tobacco, tomato, or any other of a long list of susceptible plants may have been found previously. If the soil is infested it is best to

⁸ Apparently several species of *Pratylenchus* are involved.

⁹ *Meloidogyne incognita*.

sow it to fescue or bluegrass and not attempt to grow tobacco or other susceptible crops.

The practice of planting tomato and other plants brought in from the South is dangerous because root knot nematodes are likely to be introduced. Once established in a garden or field it is almost impossible to get rid of them. Removal of the affected root systems in the fall will greatly reduce the nematode population in the soil and injury the next year.

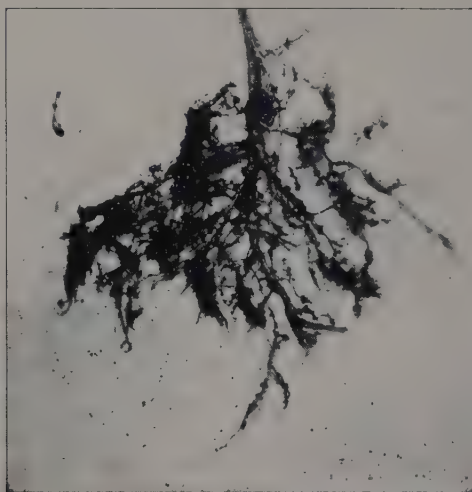


Fig. 19.— Root knot or nematode injury to tobacco roots.

Pythium Soft Rot

This disease occurs soon after setting. The affected plants wilt and, when removed from the ground, will be found to have a soft, watery rot of the buried stem (Fig. 20). The disease is caused by a species of *Pythium*, one of the organisms responsible for damping-off of seedlings of many different plants. Resetting is of little value because, when the disease first appears, there are plants in all stages of decay, some of which will not die for a week or more. It is best to disk the field and reset completely. The new rows should be a foot or more from the original ones.

Club-Root

Club-root has some features in common with root-knot and could be confused with it. However, knots occur on small rootlets as well as on the larger roots in the case of root knot whereas club-root is



Fig. 20.— *Pythium* soft rot of recently set plants.

confined largely to older roots that are very much enlarged throughout (Fig. 21). Actually the enlarged roots are made up of a succession of closely packed tumors or enlargements that are easily broken apart. The disease has been found in Campbell, Owen, Henry, Boone, Carroll, Grant, Daviess, Clinton, Garrard, and Fayette counties and has been found in eastern Tennessee and in Maryland. Plants affected by club-root usually grow slowly and rarely mature properly. The growing-point leaves are sometimes severely distorted (Fig. 22). In 1947 the disease appeared to have developed in definite more or less circular areas either in the center of the field or near one edge, but in 1948 there was evidence that infection had taken place in the plant bed. A portion of a field set from one bed might be entirely free from infection while the portion set from another bed might be heavily infected.

The disease is caused by a virus similar to the wound-tumor virus. The latter virus is transmitted by certain leaf hoppers, so it is probable the tobacco virus is also. Tobacco following a diseased tobacco crop is usually unaffected.

Broomrape

Broomrape is a parasitic flowering plant (*Orobanche ramosa*) that grows upon the roots of tobacco, hemp, and other plants (Fig. 23).

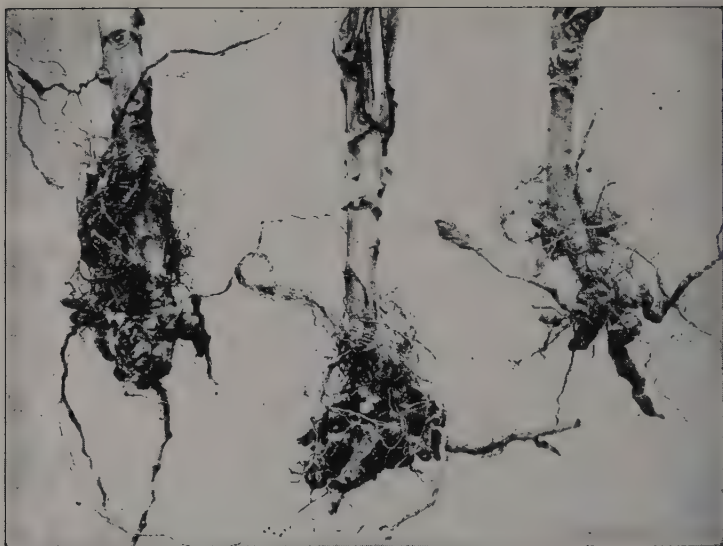


Fig. 21.— Club-root of tobacco.



Fig. 22.— Club-root virus sometimes causes severe distortion of the growing-point leaves.

As it is incapable of forming green coloring matter, and, therefore, cannot elaborate its own food materials, it must take them directly from the roots of the plant upon which it lives. It produces seeds in abundance that are capable of remaining viable in the soil many years; consequently, broomrape may appear in fields that have not been planted to either tobacco or hemp for a long time. The parasitized tobacco plants take on a sickly, yellowish, starved appearance, at which time large masses of the blue-flowered broomrape can be seen around the base of the tobacco plant. It is injurious to an occasional field of tobacco in the Bluegrass section of Kentucky.

Prevention: No way is known to prevent broomrape in fields known to be infested. Avoid planting tobacco in them. There is evidence that broomrape multiplies on some weeds, thus keeping ground infested between tobacco crops. Where it is practicable, broomrape should be pulled up and carried from the field after the tobacco crop



Fig. 23.— Tobacco parasitized by broomrape (*Orobanche romosa*).

is cut and before the broomrape seed is ripe in order not to reinfest the ground with seed. In a "continuous tobacco" field this has been found, in India, to greatly reduce infestation. It is reported in Italy that various legumes stimulate germination of broomrape seed but broomrape does not produce seed on these crops, and so a field may be freed of broomrape in this way. In California large areas have been freed from broomrape by treating with methyl bromide.

False Broomrape

In 1952 and 1953 the county agricultural extension agent in Adair county, at that time John Cochran, sent tobacco plants to the Experiment Station that had outgrowths on the roots. These were at first diagnosed as broomrape but when it was observed that if the growths got above ground—which they usually did not do—they turned green, the true nature of the trouble was recognized. The outgrowths appeared to be tobacco shoots that arise from any position on the tap root or smaller roots (Fig. 24). The trouble has been reported from other counties near Adair and as far west as Christian county and north to Daviess county.

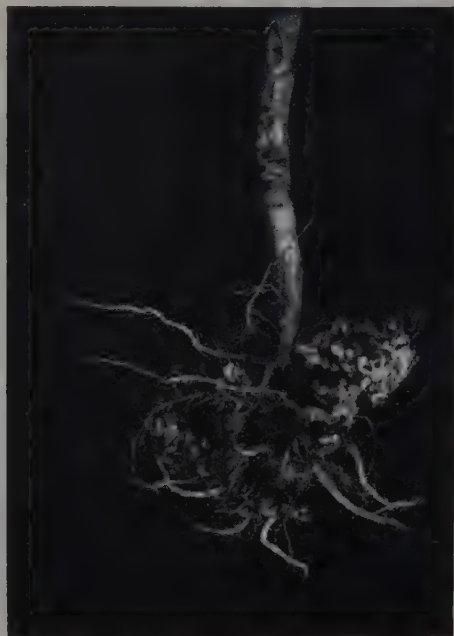


Fig. 24.— False broomrape.

The cause of the false broomrape has not been determined. In some fields every plant appears to be affected, in others only an occasional plant. Some plants with masses of shoots appear to have had the trouble all summer, others with a few outgrowths seem to have developed the disease more recently. Some growers with heavily infested crops were not aware of anything being wrong with their tobacco. No recommendations can be made at present for prevention.

Dodder

Dodder is another parasitic flowering plant that ordinarily causes little injury to tobacco but is a common parasite of Korean lespedeza. Where tobacco beds are located in an old lespedeza field, dodder may attack the tobacco plants in the bed and become attached to them. Then, even though most of it is pulled from the tobacco plants before setting, small bits will remain attached and be carried to the field where they will grow rapidly and practically destroy the plants. It is best not to put a tobacco bed in a lespedeza field where dodder was present. If dodder appears in a tobacco bed the affected areas should be avoided when pulling plants.

LEAF DISEASES

Angular Leaf-Spot and Wildfire

Angular leaf-spot, sometimes called "rust" in the burley section, and wildfire are widespread in Kentucky and in certain years cause considerable injury to tobacco. The diseases appear in the plant bed on tender, rapidly growing plants rather suddenly about 5 days after cool, rainy periods (Fig. 25). Under conditions of high humidity small water-soaked spots develop in the leaves, apparently as a result of intercellular spaces being flooded with water. If bacteria are then splashed or carried in other ways to the leaves, they readily enter through the stomata into the water-soaked areas and cause infection. These spots rapidly turn brown whereupon they give the plants a scorched appearance, or in wildfire the small plants may die, partly as a result of toxin produced by the wildfire organisms.¹⁰ Following a severe outbreak, some of the plants usually recover rapidly and as the

¹⁰ Wildfire and angular leafspot are caused by the organisms *Pseudomonas tabaci* and *P. angulata*, respectively. These organisms are generally put in distinct species but there is good evidence that they are variants of the same species. Wildfire cultures, after a time in storage, not infrequently produce both wildfire and angular leaf-spot, even from cultures started from a single cell. The angular leaf-spot phase at one time seemed to be more abundant in the soil than the wildfire phase but during 1950 and since the reverse is true.

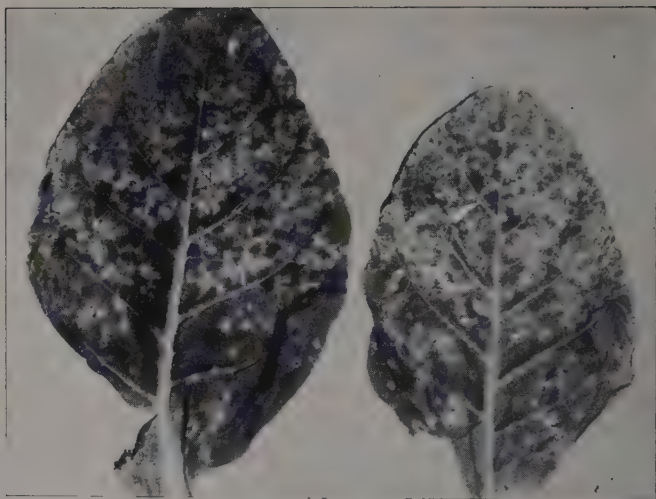


Fig. 25.— Angular leafspot on leaves of half-grown plants from a heavily infected bed. The disease at this stage is commonly called rust.

earlier-affected leaves die, the plants may show but few signs of infection at setting time. The angular leaf-spots on older leaves have small, irregular, nearly black centers, surrounded by a narrow halo or band of yellow (Fig. 26A). With age the centers may turn nearly white. The tissues around the spot, especially on plants in the bed and on rapidly growing tobacco in the field, are often puckered and torn. The wildfire spots are usually surrounded by a broad yellow halo (Fig. 26B). One or the other or both diseases are usually present in untreated burley plant beds where they sometimes cause considerable injury if the plants are small. Dark-tobacco plants in the bed appear to be more resistant to angular leaf-spot but are very susceptible to wildfire. It is difficult to find angular leafspot on dark tobacco plants even when they are growing in the same bed with heavily infected burley plants. The diseases are carried to the field on young plants where they may spread rapidly, during rainy, windy weather (Fig. 27).

In the field, angular leafspot and wildfire may develop rather suddenly on rapidly growing tobacco which previously had appeared entirely free from infection. This sometimes occurs when clean plants are set followed by several days of wet stormy weather. An outbreak, of rather general occurrence in Fayette county, appeared following a rainy period of about 3 days. On one of these days when the soil was wet, rain fell for about 3 hours. During the rain, plants about 1-foot tall were observed to have numerous water-soaked, trans-

lucent spots on some six or seven lower leaves. The water-soaking was of the internal type as the spots were distributed evenly on the leaves on all sides of the plants and there had been no driving rain which could have forced water into the leaves. A few days later all the plants in certain areas of the field were heavily infected with leaf-spots, the distribution of which corresponded with that of the water-



Fig. 26.— Three leafspot diseases of tobacco. Angular leafspot (A) and wildfire (B) are two bacterial diseases sometimes destructive to tobacco. Blackfire (C) on burley tobacco is probably started by the wildfire and angular-leafspot organisms on tobacco growing on land deficient in potassium.

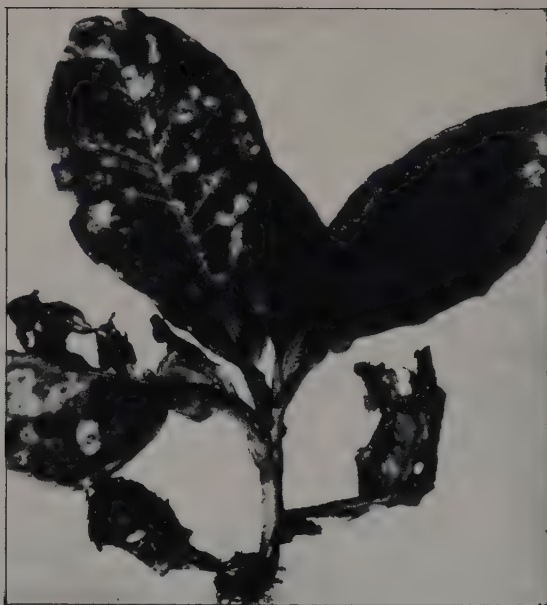


Fig. 27.— Wildfire on a tobacco plant nearly ready to set. Plants half grown or larger are rarely killed, but their growth may be retarded.

soaked spots. The bacteria that caused the spots evidently were in the soil and were splashed onto the water-soaked areas which they quickly entered, causing infection. Ordinarily water-soaking lasts for about 3 hours or less, but leaves have been observed to remain water-soaked overnight. The bacteria may also spread during driving rains when the leaves on one side of the plant develop heavy infection. There is, however, a type of spot that follows violent rain and windstorms which is the result of rain beating on leaves turned up or over by the wind. If the stomata are closed, the beating raindrops bruise the leaf tissue but if the stomata are open the water passes into the leaf and causes only a water-soaked spot which soon disappears. The bruised areas may gradually turn yellow and die when they have much the appearance of angular leaf-spot.

The bacteria that cause these leaf spots have been found to live on the roots of grasses and weeds as well as on the roots of tobacco and small grains. This explains why the bacteria may attack tobacco plants in the field that came from a clean bed, and why the diseases are found in the majority of untreated plant beds.

Prevention: If the diseases are prevented in the plant bed, there is usually little danger of their developing in the field except during protracted wet periods, particularly soon after setting. Plant beds that are well ditched, so that no water will flow over them, that are prepared in the fall early enough so that the roots of plants turned under will die and decay before winter, or beds that are thoroughly steamed or methyl bromide treated in the fall should be free from leaf spots, particularly if treated with bluestone-lime mixture.¹¹ When plant beds are used each year, disked and sowed to soybeans following setting, and then plowed in the fall and treated for weed control, there is no difficulty whatever with leaf spots year after year if the beds are ditched and treated with bluestone-lime. Beds plowed late in the fall or plowed in the spring and burned are likely to be contaminated with the leaf-spot bacteria unless treated early and very thoroughly with bluestone-lime, as the bacteria are almost certain to be carried on the roots of plants turned under.

In the field, injury to the leaves is not so great if the plants are well nourished, particularly with potash.

Breeding for Resistance. The wild species, *Nicotiana longiflora*, was found to have resistance to these two diseases. This resistance has been transferred to tobacco and promised to be a satisfactory means of preventing these two serious diseases. Burley 21 and other lines of tobacco carrying this factor have now been grown for several years. While they are much more satisfactory than the old susceptible lines, many beds and fields of Burley 21 have been seen heavily infected with angular leaf-spot and one bed and field of Burley 21 was heavily infected with wildfire. The resistant varieties will undoubtedly be useful in control for years to come but growers can expect the resistant varieties to prove susceptible to certain strains of both organisms.

¹¹ Bluestone-lime or bordeaux mixture is cheap and is easily applied with a sprinkling can. It should be applied when the plants can just be seen and again 10 days later before the disease appears. Bordeaux mixture suitable for sprinkling on tobacco plant beds is prepared as follows: 50 gallons, sufficient for 66 yards of bed 9 feet wide, require 4 pounds of chemical hydrated lime (or $3\frac{1}{4}$ pounds of stone lime slaked with a small quantity of water), 3 pounds of finely powdered copper sulfate (bluestone), and 50 gallons of water. Dissolve the bluestone in a bucket of water. Mix the lime into a thin paste with water in another bucket, and pour it into the water in a barrel or other container, containing about 46 gallons of water. Then, while stirring vigorously, pour in the copper sulfate solution. The bordeaux may be prepared in a wooden barrel, or 60-gallon oil barrel, and may be applied to the bed with an ordinary sprinkling can. It is best to wash out the containers before use, so that the sprinkler will not become clogged. The mixture should be stirred every time a portion is removed from the barrel.

Frogeye and Greenspot¹²

Frogeye, caused by a fungus, is common in Kentucky but is rarely the cause of serious injury to tobacco. The spots are found on the lower leaves in damp locations. They have a dead, white, parchment-like area in the center, about 3/16 of an inch in diameter. In this area is an indistinct grayish mass of spores (Fig. 28). The tissue surrounding the spot is a light orange yellow blending into the normal green of the leaf. As the yellow area sometimes becomes quite wide, the spots might be confused with wildfire. Frogeye is sometimes considered to benefit burley tobacco when it affects only the lower leaves; but some years the upper leaves are peppered with small green spots after the tobacco is cured (Fig. 29). These green spots have been

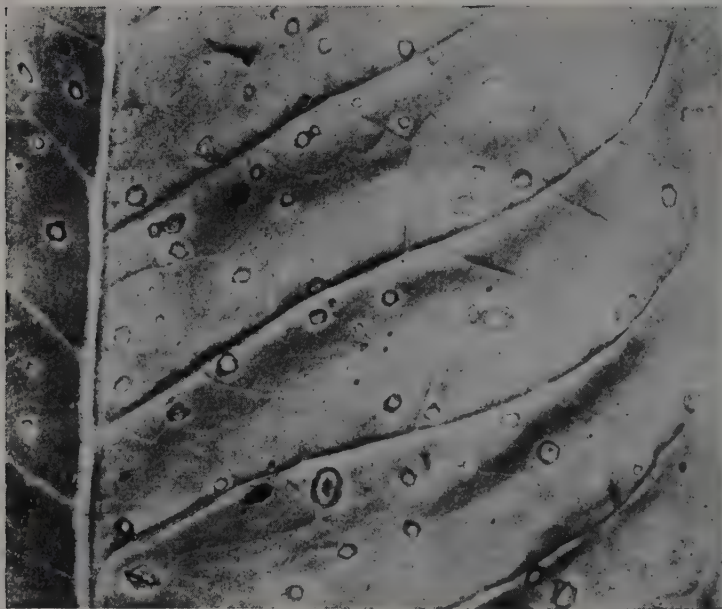


Fig. 28.— Frogeye of burley tobacco. The parchment-white spots with the gray centers are typical of this disease.

¹² This disease is usually considered to be caused by the fungus, *Cercospora nicotianae*, but studies at the Kentucky Agricultural Experiment Station have demonstrated that cercosporas from several other genera of plants will also cause typical frogeye spots on tobacco and that the fungus from tobacco will cause infection of other genera. It is probable that the tobacco fungus is identical with the celery fungus and should be called *C. apii*.



Fig. 29.— Greenspot on a cured leaf of burley tobacco. This spot is caused by late infections by the frog-eye fungus.

proved to be caused by the frog-eye fungus which attacked the leaves a few days before cutting, though the spots are usually not evident at cutting. During curing the chlorophyll fails to break down in the infected spots. In wet seasons when infection has occurred on the upper leaves of burley tobacco and the tobacco is left in the field to become thoroughly ripe after the last suckering the lower leaves may die rapidly and large dead spots may suddenly appear on the upper leaves. Under these conditions frog-eye may cause extensive loss.

If one considers that cercosporas from other genera of plants can cause typical frog-eye on tobacco, it is probable that infection originates from wild plants. This would explain the common appearance of the disease in the field. Frog-eye is a rare disease in plant beds in Kentucky. Control measures are not known.

Leaf Scald

Every year some scalding of burley tobacco leaves occurs. The scalding, usually on about two leaves of a plant, develops while the leaves are badly wilted. The parts of the wilted leaf folded together and exposed to brilliant sunlight fail to recover, turn a bluish-green, and later dry and turn brown (Fig. 30, A, B). A greenish black mold develops over the surface of the dead tissue. Wilting occurs in hot weather following periods of rapid growth. It is also sometimes caused by the sting of one of the stinkbugs. If the bark is carefully peeled from the stalk of a wilted plant that has been stung, white, elongated



Fig. 30.— Leaf scald of burley tobacco. (left) Two leaves badly wilted. Wilting of this kind is usually attributed to the sting of an insect. (right) A leaf such as shown on the left following recovery from wilting. Some parts of the leaf were so badly wilted that death followed. The dead areas are at first bluish green and later turn brown.

areas of collapsed spongy tissue may be found. These are evidently the feeding areas of the stinkbug.

Weather Fleck

Weather fleck (Fig. 31) seems to be a relatively new disease in Kentucky. It has been seen in Burley 21, both on the station farm



Fig. 31.— Weather fleck.

and in farmers plantings, in hybrids with Burley 21, and it has also been seen in some experimental dark tobacco from the University of California. But it is rare in the old standard varieties of burley and dark tobacco grown in the state and in varieties derived directly from them. It appears on lower older leaves on plants near the ends of rows that are exposed to the sun and is believed to develop when the ozone content of the air exceeds 0.05 ppm. It should never become a serious problem in Kentucky because varieties can be selected that are resistant.

VIRUS DISEASES¹³

Mosaic

In the past, mosaic (Fig. 32) has been the most common and injurious of the virus diseases of tobacco. At the present time, because of the development of mosaic resistant varieties of burley, air-



Fig. 32.— A mild and a severe form of mosaic of tobacco. There are many distinct field strains of the typical tobacco mosaic. These differ in severity of symptoms produced on the plant, and in color produced in the affected leaves. Usually affected leaves are various shades of green, but some strains produce yellow blotches and others turn parts of the leaf almost white.

¹³ See also club root, page 28.

and fire-cured dark tobaccos, and One Sucker tobacco, the disease is of little importance except occasionally where old susceptible varieties are still being grown. It is known to most tobacco growers, although often by some other name than mosaic. In some parts of western Kentucky it is called "walloon"; in other parts of the state, "black french," "dry-weather french," "frenching," etc. The disease is characterized by a mosaic pattern of light- and dark-green areas in the leaves that develop after infection occurs.

The tobacco-mosaic virus is quite variable. As a consequence, there are numerous field strains of the virus and symptoms of affected plants differ greatly in different fields. Certain strains cause mild mottling and no distortion of the new leaves while others cause prominent mottling and distortion of the new leaves. The patterns may be pure white or yellow or more commonly various shades of green. Certain strains cause burning or spotting of leaves, a condition known as *mosaic burn* (Fig. 33). Other strains never cause burn. Burn is confined largely to leaves too old to develop mottle patterns but not of full size at the time of infection. When a burning strain of mosaic is spread during topping of dark tobacco one or two upper leaves may burn with no other symptoms of mosaic except in the suckers, which, in dark tobacco, are removed. Growers often confuse mosaic burn with angular leaf-spot, or wildfire in dark tobacco, and some begin cutting to prevent further spread. This early cutting is not necessary.

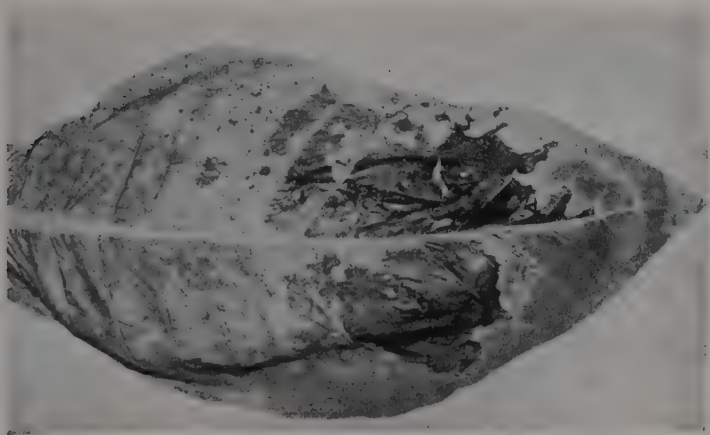


Fig. 33.— Mosaic burning often develops on one or two leaves of a plant recently infected with certain strains of tobacco mosaic. Few tobacco growers recognize this as a symptom of mosaic because at the time these symptoms appear the mosaic symptoms may not be in evidence, especially in topped tobacco.

The cause of mosaic is a virus, particles of which are too small to be seen with an ordinary compound microscope but can be seen with an electron microscope, and are readily transferred from diseased to healthy plants by handling.

The mosaic virus has been shown to remain virulent for 52 years in cured tobacco. Hence, it is practically always present in the natural-leaf chewing or smoking tobacco of susceptible varieties used by tobacco growers if this tobacco was made up in part from infected plants. As the virus is readily transferred from dried tobacco to living plants the tobacco worker himself is nearly always the chief agent in introducing the disease into the plant bed or field. It has been clearly demonstrated that the hands of a man who uses natural-leaf tobacco containing the virus, either for chewing or smoking, become contaminated by handling the dried tobacco, and that he can transmit the virus readily to healthy plants while he is weeding, or pulling plants for setting. Once introduced, the disease is easily spread during the operations in which the plants are handled, such as pulling, worming, topping, suckering, and cultivating. In a field where the disease was prevalent earlier, many of the suckers are likely to be diseased following cutting. The virus does not appear to be carried in tobacco seed.

Certain weeds (horsenettle and groundcherry) become infected and carry the virus from year to year. But these appear to be minor sources of the mosaic virus except in beds where there are infected weeds. While the operator is weeding, the virus may be spread from these weeds to an occasional tobacco plant. During the summer the virus is spread slowly in the field from the weeds to tobacco, perhaps by tools; hence it is practically impossible to completely prevent its occurrence in fields where there are many infected weeds. Chopped tobacco stalks and other tobacco trash, carrying the mosaic virus and applied to the field at the last disking before setting may cause extensive field infection. Tobacco stalks, unless they come from a field known to be free from mosaic, or from a mosaic-resistant crop, or are put on the field during the winter and are later plowed under, should not be used as a fertilizer for tobacco.

In Kentucky overwintered roots of affected tobacco plants even though dead, retain some of the virus. At the Experiment Station farm no greater difficulty has been met in preventing mosaic in plots set to tobacco each year and inoculated with the virus in the middle of the summer so that there will be a carryover in the roots, than in plots set to tobacco at less frequent intervals. The roots of tobacco readily become infected with mosaic, when inoculated, but the virus spreads very slowly from the roots to the top unless the tops are removed and

sucker growth develops, whereupon the virus quickly moves into the new growth. It, therefore, seems safe to grow tobacco, following a heavily infected crop, without fear of infection, except in an occasional plant, if the proper precautions to prevent infection from other sources are taken.

Growers frequently express the opinion that mosaic does not injure tobacco. This is not true, except that in burley there may be no injury if infection occurs shortly before cutting. There is some evidence that the upper leaves of burley might be slightly improved in quality by late infection. Infection of all plants of either burley or dark tobacco at setting time reduces the value of the crop about 60 percent, and infection when about half grown, by about 50 percent. When plants are inoculated at topping time, dark tobacco may be injured about 25 percent. Contrary to popular belief mosaic patterns present in green tobacco are still visible in the cured leaf (Fig. 34).

Prevention: Satisfactory mosaic-resistant varieties of any of the types grown in Kentucky are now available so that losses from mosaic can be completely eliminated. If a person desires to grow a susceptible variety, mosaic can be prevented by excluding from the plant bed all tobacco trash of previous crops, such as ground tobacco stalks and trash used as fertilizer, and complete abstinence from the use of natural leaf tobacco during the weeding and setting season by those who handle the plants. Before going to the plant bed, growers should remove all tobacco from their pockets and thoroughly wash their

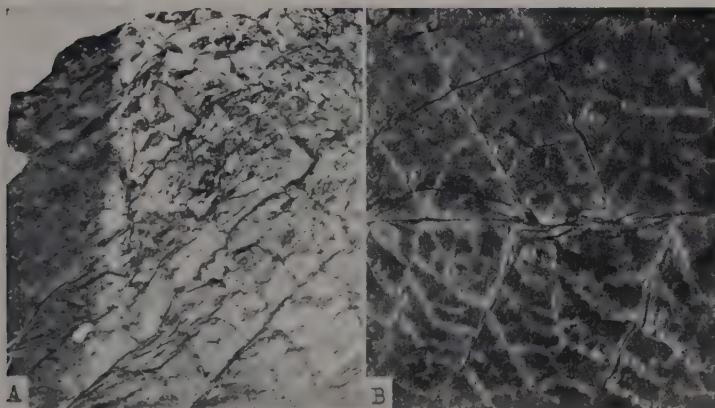


Fig. 34.— (A) Tobacco-mosaic patterns in a cured leaf of dark fired tobacco. The portion with patterns was taken with transmitted light and the remainder with reflected light. (B) Portion of a cured leaf of white burley tobacco showing mosaic patterns with reflected light.

hands with soap and water. Another simple way to prevent infection from the hands of workers is to have each of them, while weeding, pulling, or setting, dip his hands in a concentrated solution of trisodium phosphate (T.S.P.) in water or dip them in milk. If this is done by each worker about four times a day there will be little infection from this source. Tests of commercial tobacco indicate that manufactured twists and scraps are probably always free from mosaic, and plugs rarely carry it. Cigarettes and tinned tobacco, while they carry mosaic, have been proved relatively safe to use. Chewing or smoking tobacco made from one of the resistant varieties is safe to use as it is virus-free.

Horsenettles and groundcherries should not be handled while weeding or pulling plants and a bed should not be placed where infected weeds of these species are known to be present. If these weeds are found in the bed at weeding or pulling time they should not be touched. Mosaic may be introduced and spread while worming tobacco by hand. Therefore, it is preferable to control the tobacco hornworm with one of the newer insecticides. Mosaic may be spread from plant to plant by tools and harness while cultivating tobacco. It is, therefore, good practice to go through the field about 3 weeks after setting and remove all diseased plants. Healthy plants should not be handled during this operation or until the hands have been thoroughly washed. If mosaic plants are present in a field of dark tobacco at topping time they should be topped last. It is not so necessary to observe this precaution with burley tobacco especially if it is topped late. Fields of burley tobacco heavily infested with mosaic should be topped late. If topping is done with a knife and only the top of the plant is handled, there will be little spread of mosaic. If these simple precautions are taken, damage from mosaic will be negligible.

Mosaic-resistant Varieties

All the old commonly grown North American varieties of tobacco are highly susceptible to mosaic, but two sources of mosaic resistance have been found. One is a highly resistant variety of dark tobacco called Ambalema, grown in Colombia, South America. The other is *Nicotiana glutinosa*, a small, weed-like plant with small heart-shaped leaves with long petioles. No satisfactory mosaic-resistant varieties of tobacco have been developed by crossing with Ambalema.

Nicotiana glutinosa, a wild species from Peru, when inoculated with the mosaic virus responds by developing dead spots at each point of virus entrance. The virus is then usually localized in the spots and does not spread, and the plant as a whole remains free from mosaic (Fig. 35). By crossing tobacco and *N. glutinosa*, doubling the chromo-



Fig. 35.—A leaf of a mosaic-resistant burley (glutinosa type resistance) showing the type of reaction produced by tobacco mosaic virus. The virus usually remains localized in the dead spots, and the remainder of the plant remains healthy.

some number, and then repeatedly backcrossing with tobacco, the reaction (NN) can finally be established in tobacco. Several burley varieties—Ky 35, Ky 9, Ky 10, Ky 12, and others and the dark varieties Ky 151 and Ky 160—carrying this factor have been developed and are now widely used. These varieties not only largely prevent losses from mosaic, but chewing tobacco made from them can be used safely by men working in plant beds of susceptible varieties.

Caution: Because of the nature of resistance in the mosaic-resistant varieties the plants may die if heavily inoculated with the mosaic virus either on the midvein or on the stalk. In western Kentucky, a streak disease sometimes develops in dark tobacco following topping of mosaic-resistant tobacco. The disease starts where the top is broken out and spreads down the stalk as a black streak sometimes killing the plant. This seems to occur only when a grower has part of his field set to a mosaic-resistant variety and the remainder in a susceptible variety or is using a variety that is a mixture of resistant and susceptible strains. In topping, if any of the susceptible plants have mosaic, the hands of the topper become contaminated with the virus, and it is spread to the resistant plants when these are topped later. If a mosaic-resistant dark tobacco is grown, the whole field should be set to it and not to a mixture of resistant and susceptible plants.

Plantago Virus

A virus frequently found in the common species of plantain (*Plantago sp.*) seems to be closely related to the tobacco-mosaic virus and it may be the virus from which the numerous strains of tobacco mosaic virus were derived. In Ky 16 it causes a mottling somewhat similar to that caused by the tobacco-mosaic virus, but in several other varieties of burley and dark tobacco it causes a destructive necrotic disease (Fig. 36). The plants are stunted, have dark-colored streaks



Fig. 36.—Necrotic disease caused by plantain mosaic in burley tobacco. The stalk and midveins have long streaks of discolored tissue; the plant is greatly stunted and practically valueless. In other varieties of tobacco, as Ky 16, the same virus causes a mottle disease without streaking and stunting.

on the stalks and midveins and either scattered yellow or dead spots on the leaves. Affected plants do not recover, and if infected when young are valueless. The virus seems to be spread from plantains to tobacco when weeding or pulling plants. The disease is not common in tobacco but can cause considerable loss when numerous infected plantains are in the immediate vicinity of the bed. A plant bed should, therefore, not be located in an area where these weeds are abundant. The virus withstands drying just as the tobacco-mosaic virus does and so it could be carried from season to season in cured tobacco.

Ring Spot

Perhaps the most common and easily recognized of the virus diseases of tobacco is ring spot. The name describes the disease, as frequently dead rings occur, although the symptoms vary greatly (Fig. 37). Though ring spot is found in nearly every tobacco crop examined,

it is usually not severe enough to require preventive measures. Sometimes it is destructive to individual plants, but rarely to many plants in a field.

The first symptoms may appear on tobacco plants in the bed (Fig.

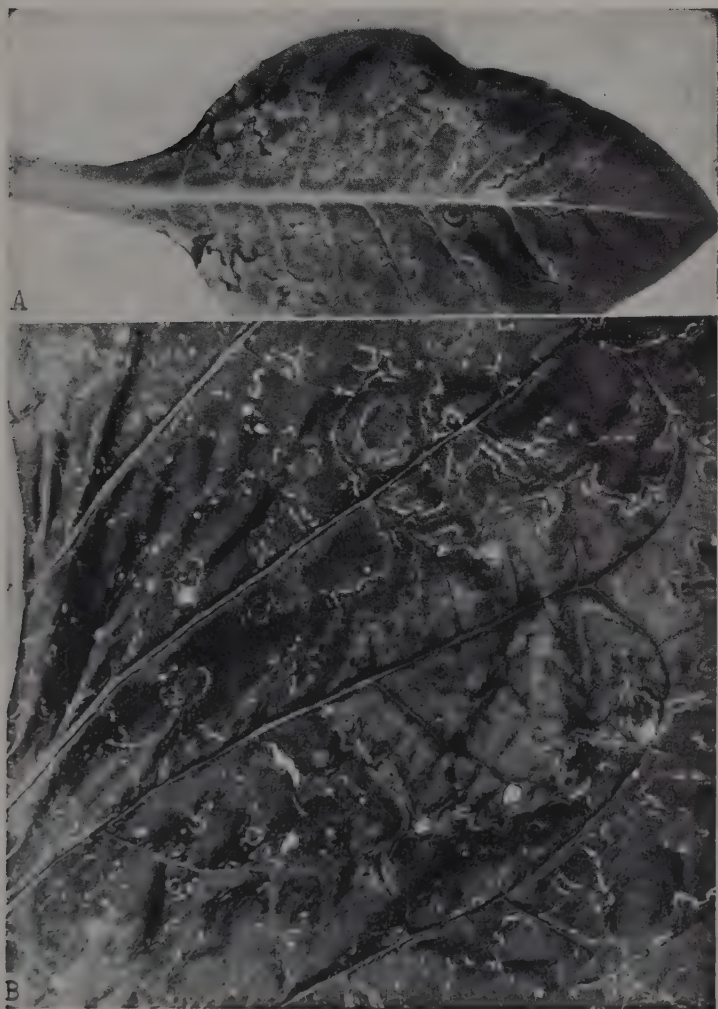


Fig. 37.— Ring spot of tobacco. (A) A leaf from a plant in the bed. (B) A leaf from the field. The dead lines, often in the form of rings, are characteristic of the disease.

37A) or on plants in the field (Fig. 37B) almost as soon as growth begins after setting. With the exception of tobacco mosaic, it is the first virus disease to be recognizable in tobacco fields following setting. Nearly all infection seems to take place within 3 weeks after setting. The disease is widespread in Kentucky, and appears to be a common cause of mosaic in cucumbers and a necrotic disease of soybeans. It sometimes affects potatoes also.

The ring spot virus has a wide host range but there is probably no direct relation between affected weeds and outbreaks in tobacco. The virus appears to be one of the so-called soilborne viruses. There is some evidence that it is transmitted by a nematode,¹⁴ but it is certain that infection comes from the soil in some way. The virus does not remain viable in the cured leaf but it is transmitted through seed. It is not likely that infection through seed is of any importance as the infected seedlings grow slowly and probably would not be set.

Streak

During the last few years this virus disease has become increasingly prevalent in burley tobacco but does not seem to be so injurious to dark tobacco. Vigorously growing plants suddenly develop a severe necrotic disease of the growing-point leaves and stalk. The stalk is marked by depressed dark areas; the midveins of the leaves have dead streaks in them, and the small veins of the leaves are darkened. The leaves curl downward (Fig. 38); the pith sometimes has large areas of dead tissue in the affected portion of the stalk. Though the affected leaves remain small and distorted, and the plant seems to be dying, growth usually is resumed and new, almost normal leaves, which sometimes show faint mottling, are produced. This change from a severe necrotic disease to almost normal growth distinguishes streak from the plantain virus disease.

Streak is particularly prevalent near volunteer stands of second-year sweet clover. This plant along the roadside is often a menace to tobacco set close by. About the time of seed formation presumably the insect which spreads the disease must leave the clover in search of better food plants and, in the search, infects an occasional tobacco plant. A ring spot-like lesion can usually be found on a lower leaf of a streaked plant. There is sometimes a marked spread of the disease in late August and early September. In addition to the loss of leaves the disease is injurious in that plants infected when young have so much injury to the stalk that they break when speared on a stick at cutting time.

¹⁴ *Xiphinema* sp.



Fig. 38.— Streak in burley tobacco. Young leaves are greatly stunted and distorted; veins of older leaves are discolored. The two smallest leaves on this plant are growing more normally. Affected plants appear to recover but the new growth carries the virus and is sometimes slightly mottled.



Fig. 39.— Curly top, a rare virus disease in Kentucky.

Prevention: Methods of prevention have not been worked out but the prevalence of the disease in the immediate vicinity of second-year sweet-clover plants suggests that benefits would result if second-year sweet-clover plants were chopped out in the immediate vicinity of tobacco fields *before* the tobacco is set in the field. If it is done after setting it may drive the insects to the tobacco. No benefit is to be gained by breaking out the affected tops of tobacco plants. The virus does not spread from one tobacco plant to another, and the new growth makes fairly good tobacco.

Curly Top

A new virus disease of tobacco was reported from Fayette, Clark, Christian, Hart, Carroll, Ballard, and Franklin counties in 1953. Usually only a plant or two were found in a field. While the disease appears to be very similar to the Leaf Curl found in India and South Africa, it is different in that the plants appear to recover. It is probably caused by the sugar beet curly top virus. While it is of no importance at present, any new virus disease is a potential threat to the tobacco industry. The Department of Plant Pathology would welcome reports and specimens of this new disease.

Other Virus Diseases

Several other viruses affect tobacco in the field but are usually not very injurious. Several viruses similar in nature to the cucumber-mosaic virus; three virus strains, differing in degree of severity, called the etch viruses; and the vein-banding virus, commonly present in mosaic potato plants, affect tobacco. Experiments indicate that vein-banding and etch viruses may be carried from generation to generation in potatoes. The etch virus may be present in ground cherry plants,¹⁵ growing near farm gardens, from which it is transferred to tobacco, probably by aphids. Since the appearance of the strain of the green-peach aphid which attacks tobacco, etch has been more prevalent, sometimes attacking all plants in the vicinity of infected weeds. In our experience, veinbanding appears in tobacco only when potatoes are growing in the vicinity.

STALK DISEASES

Fusarium Wilt or Yellows

Wilt is a common and destructive disease in some parts of Kentucky. It is largely confined to sandy soil where it spreads rapidly and persists for years. While the fungus¹⁶ which causes the disease

¹⁵ *Physalis* sp.

¹⁶ *Fusarium oxysporum* var. *nicotianae*.

appears to be widely distributed in the more fertile soils of the state, it rarely causes injury to tobacco growing in them although in the last few years it seems to be on the increase even in central Kentucky. Attempts to infest soil on the Experiment Station farm at Lexington were not very successful. In soil that had been artificially contaminated over 15 years in succession with virulent strains of the fungus, highly susceptible burley plants were grown with only 1 or 2 percent mortality. A possible explanation for this is the high calcium content of the central Kentucky soils. Studies on tomatoes have shown that as the available calcium increases fusarium wilt decreases. Also readily available boron tends to reduce wilt if calcium is available.

Affected plants are usually scattered in the field, but sometimes all plants in a large area are destroyed. If present in one crop it is likely to affect a much larger number of plants in the next crop set in the same field. It is more prevalent in burley than in dark air-or fire-cured tobacco but one-sucker is susceptible. The fungus enters a single root and spreads from it up the side of the plant, causing the leaves on that side to turn yellow, wilt, and die (Fig. 40). The rest of



Fig. 40.—Fusarium wilt of burley tobacco caused by inoculation with a pure culture of the fungus at setting time.

the plant may remain fairly normal although it may bend toward the diseased side. If the stalk of an affected plant is cut across, the tissue under the bark on the yellowed side will be found to be discolored.

There are several strains of fungus that attack tobacco. Strain 1 attacks burley tobacco and sweetpotatoes but not flue-cured tobacco

or cotton; strain 2 attacks burley, flue-cured tobacco, and sweet-potatoes but not cotton; while strain 3 attacks burley tobacco and cotton but not flue-cured tobacco and sweetpotatoes. This means that tobacco, grown in fields where watermelons, tomatoes, potatoes, sweet-potatoes, cotton, or other crops have had fusarium wilt, is more likely to be diseased than that grown in fields where susceptible crops have not been grown previously.

Prevention: Fusarium wilt does not cause enough injury to most varieties of dark tobacco, except one-sucker, to warrant preventive measures. The varieties of dark tobacco tested proved to be more than 50-percent resistant when inoculated at setting time, which means that in the field only an occasional plant will develop the disease. Most of the commonly grown varieties of burley tobacco are susceptible, but varieties of burley highly resistant to wilt have been developed at the Kentucky Experiment Station. Ky 35 is resistant to certain strains of fusarium wilt, and the new varieties, Burley 11A and 11B, selected at Greeneville, Tenn. are more resistant. A group of new varieties, represented by Ky 12, highly resistant to wilt, mosaic, black root-rot, and wildfire have been developed at the Kentucky Agricultural Experiment Station.

Varieties of one-sucker tobacco resistant to fusarium wilt, black root-rot, and mosaic are being developed.

Sore-Shin

Tobacco plants are sometimes affected with sore-shin, a disease that causes blackening of one side or of the entire stem near the ground. It may spread up the stalk some distance. The lower leaves droop and finally the plant dies. The disease is somewhat similar in appearance to black shank. Sore-shin has not been studied extensively in Kentucky and, aside from its occasional appearance in tobacco fields, little is known about it. An outbreak was studied in Calloway county in 1934, caused by the fungus *Sclerotium bataticola*. It occurred during a damp period when the temperature for several days was about 100° F. The stalks were decayed from the ground line upward. The pith was a decayed mass in which numerous, barely visible black masses or sclerotia were imbedded. The presence of the sclerotia distinguishes the disease from black shank. It is not likely to become a serious factor in tobacco production although the fungus is common in Kentucky soil.

Another type of sore-shin is caused by the fungus *Rhizoctonia solani*. Decay starts at or near the surface of the ground and spreads upward in the pith and woody part of the stalk. The lower leaves wilt and finally the whole plant dies; however, it does not yellow so

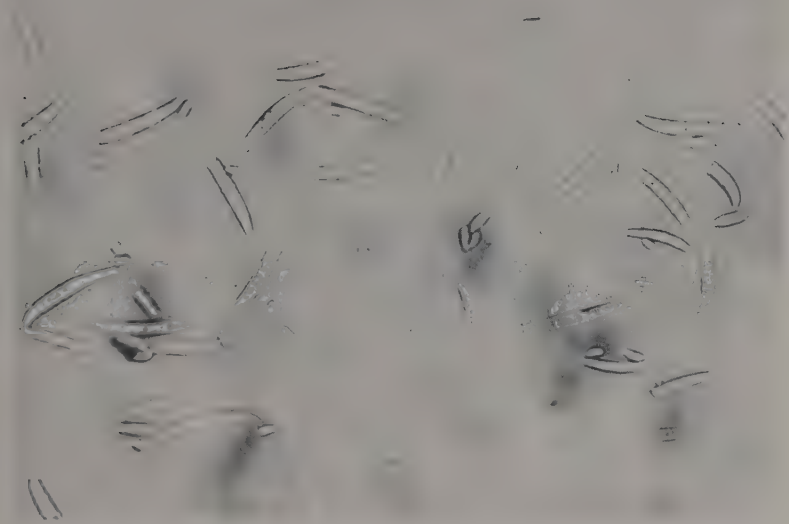


Fig. 41.— Conidia and microconidia of the tobacco-wilt fusarium.

rapidly as do plants with black shank. Though it is similar to black shank and could easily be confused with it, the two diseases can sometimes be separated on the basis of symptoms. *Rhizoctonia* usually causes dead, depressed spots on the stalk above the solidly decayed portion; if the stalk is split the pith is sometimes separated into disks in the freshly decaying area but the disks are light colored rather than black as in black shank; wefts of a brownish fungus can be seen in the decayed pith; the roots are usually not decayed by *rhizoctonia* but are by the black-shank fungus. Though this type of sore-shin is not general, a few farmers have had considerable losses from it in dark tobacco. No control measures are known. In 1960 sore-shin caused by *R. solani* was found in plant beds in Jessamine county. A lesion just above the surface of the ground was light tan and sometimes girdled the plant. Infected plants failed to grow if set.

Black Shank

Black shank was first observed in Kentucky in 1935 near Guthrie, and about 8 miles west of Elkton. The two fields were sowed to grass and nothing further was reported from these farms. The disease also appeared in northern Tennessee the same year. It has caused considerable loss in south Logan county since 1935. In 1940 it was found

in several backyard plantings in Georgetown, and on one farm in Owen and another in Nicholas county. These two fields were planted to grass and no more black shank was reported from the farms or from the counties for several years. Drainage from Georgetown plantings flowed into the north branch of the Elkhorn and subsequently black shank was found down the creek, along the Kentucky river, and eventually along the Ohio river. In 1942 black shank was found in Marion county in a corner of a field where a truck had been swept out that was used for hauling farm products from the southeastern states. Since then black shank has spread down Hardin's creek from this farm and has been carried onto higher land. In 1951 tobacco on about 600 farms in the county had black shank. By 1950 black shank had been reported in 42 counties and by 1952 in over 60 counties and on many hundreds of farms. For the most part the infested fields are small plots along creek bottoms.

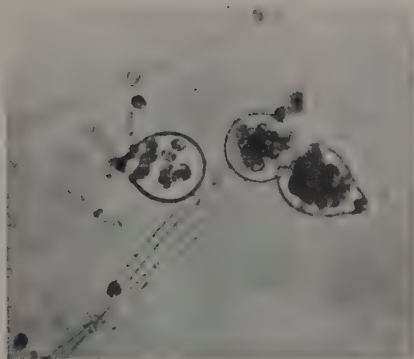
The disease, when it first appears in a few plants in a low area, is usually thought to be drowning, but when it appears the following year destroying plants over a large part of the field its true nature is recognized. Some seasons there is comparatively little loss from black shank but the damage it can do is well illustrated by what happened in an 18-acre field of burley. In 1950, a very wet season, black shank appeared on a small area of overflow land and killed some plants. In 1951, 15 acres of this burley field was a total loss by August 1 and were disked, and the other 3 acres was destroyed during the next 2 weeks. The total loss was about \$16,000. While most growers have not experienced total loss the possibility of it is ever present when tobacco is set on infested land.

Cause: Black shank is caused by a fungus¹⁷ or mold — one that is ideally adapted to spread by water. That is the reason the disease is usually first seen in a neighborhood along a creek or in low places. The fungus is also carried in dirt clinging to shoes, machinery, animals' feet, auto and tractor tires, and such. Under very favorable conditions spores are produced on the aerial fungus which possibly are airborne. Tobacco is probably the only crop plant in Kentucky attacked by the fungus.

Prevention: Under the conditions existing in Kentucky, where most land is unplowed, control and eradication of black shank are practical because it is possible to prevent contamination of new tobacco plots if clean tools are used. Black shank became established in the state during the period when the practice of growing tobacco year after year on the same plot of ground was becoming accepted practice.

¹⁷ *Phytophthora parasitica* var. *nicotianae*.

Fig. 42.—Three sporangia of the black-shank fungus. Each contains swarm spores some of which are escaping. The swarm spores are discharged soon after rain commences and are carried with running water to other plants.



It has spread most rapidly in areas where the farms are small and good tobacco land is limited, and where farmers trade labor and machinery from one farm to another. In areas where the farms are large and little or no labor or machinery is traded, spread has been slow and eradication practical.

The principles of eradication may be stated simply. Sow black-shank-infested fields to grass, preferably a grass like fescue that makes a continuous tough sod so that animals' feet will not carry dirt from the field. All tools that have been used in working the tobacco crop, hauling tobacco from the field to the barn, or in seeding the field should be thoroughly cleaned before being used to prepare a new bed or prepare a clean field for tobacco. In areas where black shank is prevalent not more than one crop of tobacco should be grown, in a 3-year rotation, until black shank is eradicated. Barn sweepings and tobacco stalks from a barn in which black-shank tobacco has been housed, should be spread back on the land from which the crop came or be put on a pasture that does not drain into a creek or onto land that is to be used for tobacco. It cannot be predicted how long the fungus will remain in the soil following a diseased crop but in soil that is distinctly acid the fungus disappears rapidly and 3 years without tobacco may be enough to make it relatively safe to plant tobacco again. In soils that have been heavily limed the fungus seems to persist longer. Fields that overflow seem more likely to be freed of the fungus rather quickly than fields on higher ground. While overflow fields may be contaminated where tobacco stubble lodges, yet a rotation in overflow land is probably safer than a similar rotation on higher ground. Long soaking seems to cause the resting spores to germinate and disappear.

Caution: On farms where black shank is present stable manure should not be used on tobacco land. It is very likely to be contami-



Fig. 43.— Black Shank. The shank of the plant is blackened from the roots upward, and the roots are decayed.



Fig. 44.— The insides of two stalks split lengthwise showing blackening and disking of the pith. The stalk on the right had evidently been infected through two leaves. There is an area of normal pith between the infected areas.

nated with the fungus and start the disease on new clean land to which it is applied. Also it is dangerous to drive a tractor or team and manure spreader through a barn lot and then to a field to be used for tobacco immediately.

A very careful worker who understands the nature of the disease may continue to grow tobacco in one field year after year, provided that at the first sign of the disease in a single plant he will carefully remove the diseased plant, put it in a bag in order not to scatter dirt, and burn it. Then he should drench the soil with a solution of some soil disinfectant such as one part nabam¹⁸ in 400 parts of water. The appearance of a single black shank plant in a field will necessitate frequent observations to be sure that a larger area is not infested. Methyl bromide is very effective in ridding the soil of the black shank fungus. Small affected areas can be treated in the fall by removing

¹⁸ Nabam is sold under the trade name Dithane D14 and Parzate Liquid Fungicide. Two to 3 tablespoons of the material in a 10-quart bucket of water should be sufficient for each spot from which a plant is removed. The soil should be loosened before it is drenched.

all roots, thoroughly working the soil and treating the area in the same way a plant bed is treated.

Breeding for Resistance: In other areas, as in Florida and North Carolina, where the disease has spread rapidly, resistant varieties have been developed that are fairly satisfactory provided they are used in a short rotation; in Florida 1 year between tobacco crops is sufficient. Burley varieties of a similar degree of resistance have been developed but in heavily infested soils in dry hot seasons they have sometimes died out 100 percent. However many growers with limited acreage for tobacco have grown the resistant varieties year after year with but little loss.

Stalk-Rot or Hollow Stalk

In wet seasons a rot of the pith of tobacco stalks is not uncommon. Infection is reported to occur through wounds before the plant is topped or through the wound left by breaking out the top. Seed stalks sometimes become infected through wounds made when the lower branches of the inflorescence are broken off. The stalk disease spreads rapidly within the plant and causes a soft rot of the pith and the stem tissues (Fig. 45). The disease is caused by the same organism that causes black-leg of tobacco in the plant bed. No means of prevention



Fig. 45.—Stalk-rot or hollow stalk produced by inoculation with bacteria from a plant affected by black-leg in the bed.

is known and because of the rarity of the disease, it would hardly seem necessary to take preventive measures against its possible appearance, even if such measures were known.

Bacterial Black Stalk

The disease to which we have given this name is not a common one, but it can become quite destructive. It seems to be a disease of ripening tobacco. Specimens were received at the Kentucky Agricultural Experiment Station in late August and early September 1936, from three widely separated farms and, on August 16, 1941, the disease was found again. It has been reported several times since. Both periods were very dry although there was evidence in two of the fields of a driving storm sometime earlier, as some plants had been blown over and then bent upward. All leaves of affected plants as tall as 4 feet turn bright yellow but only the lower leaves whose midveins are decayed wilt down completely. The bark is blackened, commencing at the ground line, sometimes for 2½ feet. It is dry and smooth and has watermarks in the blackened area. Above the blackened portion the vascular tissue is discolored sometimes as much as a foot, especially the portions leading to leaf attachments. The pith is not decayed, but in the region of the older affected area it may appear grayish and slightly wilted or may actually separate into grayish disks, just above the ground line. Affected plants may be scattered, or more than one-half of the plants in a large area may be affected.

When bits of discolored tissue are mounted in water, bacteria flow out of the vascular tissue. The bacteria are moderately large rods are usually nonmotile, but bacteria from inoculated tissue sometimes show motility. In culture the colonies are nearly white with a brownish tinge when examined under the microscope. Too little is known about the disease to make recommendations for control. It has usually been found near a barn where animals have been kept.

LIGHTNING INJURY

Lightning frequently strikes in a tobacco patch and kills plants. A circle of plants sometimes as large as 50 feet in diameter may be struck. The plants in the center may be killed to the ground line, but the roots remain uninjured, while those on the border of the affected area may show little injury. The whole area has the appearance of a spot in which a disease is spreading rapidly from a center and for this reason often causes alarm when first discovered (Fig. 46). When lightning strikes in a patch of topped tobacco the stalk of an occasional plant may be killed and the tissues torn from between the secondary veins of the basal third of the leaves. Plants showing all



Fig. 46.— Lightning injury to burley tobacco. The photograph was taken 3 days after the tobacco was struck.

degrees of injury may be irregularly scattered over the area. The injuries are quite characteristic. The large leaf veins and the stalk are most subject to injury. The affected portions of the veins turn black and shrink, giving the blade a pleated or gathered appearance (Fig. 47 B, C). The stalk may have sunken, dark-colored areas on it or if completely killed may shrivel and become hard and leathery (Fig. 47 A). It is a peculiar fact that the stalk and midveins may be shriveled and dead and the leaves go on living normally for days, apparently because the root is unaffected and the water channels of the stalk remain open. If a stalk is split open after it has dried somewhat, the pith will be found to be separated into colorless disks, which gives a peculiar ladderlike effect (Fig. 47A).

HOUSEBURN

Poor curing of the tobacco crop is the cause of immense losses to tobacco growers year after year. The injury to tobacco known as houseburn is probably the greatest single factor in this loss.

Houseburn is the result of the growth of fungi and bacteria on

and in the dead leaves when they become moist during periods of high humidity. It does not occur during the yellowing period except in parts of the leaf which have been killed. As organisms are not active at low temperature, houseburn does not occur in cold weather. It occurs most extensively at temperatures between 60° and 100° F and relative humidity above 85 percent which checks evaporation from green or yellow leaves and causes dead, brown leaves to take up moisture. Suckers left on the plant tend to induce houseburn in the leaves in contact with them.

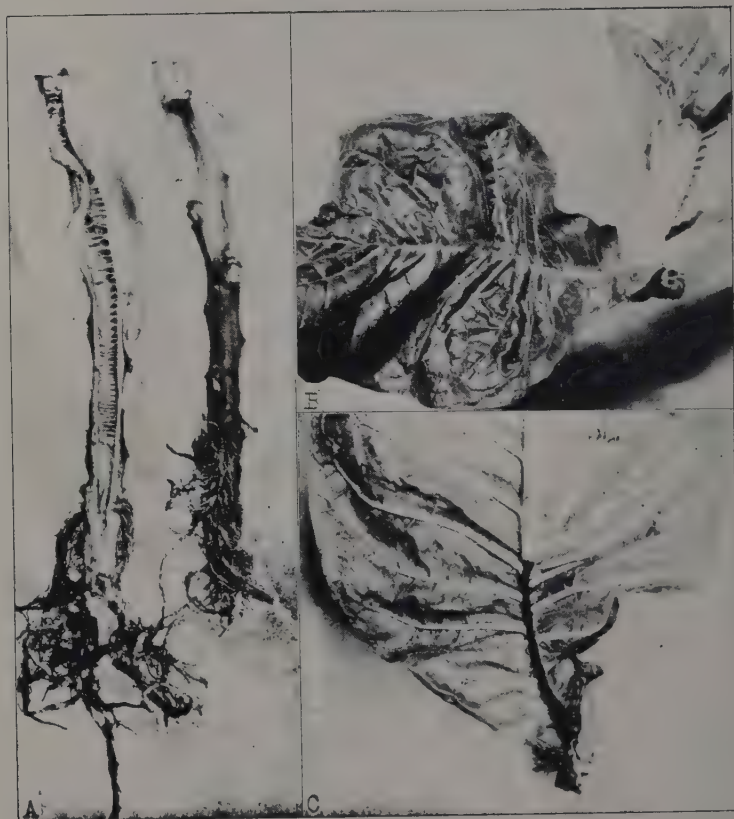


Fig. 47.— Lightning injury to tobacco. (A) The shrunken stalk and the separation of the pith into disks give a ready means of identifying lightning injury. (B) The midveins of the bud leaves have been partly killed but in the large leaf the midvein is completely killed, giving the "gathered" effect. (C) The lower portion of the midvein has been killed. The death of the midvein does not destroy the leaf which it supplies.

To prevent houseburn several essential points in curing tobacco should be understood. These are as follows:

1. Tobacco should be cut when it is properly ripened; that is when there is an accumulation of food material in the leaves principally in the form of starch. The leaf is then a lighter green, and has a flecked appearance. Ripe tobacco leaves are brittle and snap when folded between the fingers.

2. Curing is a life process during which the green coloring matter breaks down and the leaf becomes lemon yellow. The starch is used in the process and other contents of the leaf are changed. Curing and yellowing are hastened by rather rapid wilting and retarded when the leaf is full of water. Besides the loss of water in drying, the leaf loses about 30 percent of its weight during the curing process. The presence of suckers on the stalk during curing increases the loss of leaf weight in the attempt of the plant to keep the suckers alive. Drying and death of the plant are accelerated by splitting the stalk. It is therefore, likely that splitting the stalk in harvesting tends to increase the weight of the leaf, as compared with spearing. The death of portions of the leaf from bruising, frost, too rapid drying, or other cause prevents the leaf from curing, and produces green patches in the cured leaf.

3. Following yellowing the leaf quickly dies, although the stalk remains alive for a longer time. Death of the lower leaves naturally occurs first and death of the edges of the leaves precedes that of the remainder. When yellowing is completed and the tissues are dying, the remainder of the curing process is primarily the slow drying of the leaf.

4. Browning or reddening that accompanies the death of the leaf is caused by oxidation of substances in the leaf. It proceeds more completely at higher relative humidity and more rapidly at higher temperature. Each time the tobacco becomes damp or "comes in case," the depth of color increases. As a premium is paid for light-colored burley tobacco, the cured leaf should be kept dry, except possibly tobacco originally cured green or piebald.

5. Leaf activity nearly ceases at 40° F, but becomes more active as the temperature is raised. At 125° F the cells of the leaf are rapidly killed, while at 115° F longer exposures kill the leaf. The best temperatures for the first stage of curing or the yellowing process are between 60° and 90° F. A barn to which artificial heat is not applied rarely becomes too hot but it may readily become too cold for proper curing.

6. Relative humidity or the percentage of saturation of the air at a given temperature is one of the most important factors in curing.

Microorganisms begin to develop on the leaf at a relative humidity of 80 to 85 percent but sufficient darkening of the leaf to result in lowered value can occur in some seasons at relative humidity as low as 75 percent. If the relative humidity goes much lower than 65 percent, the tobacco may dry too rapidly, resulting in mottled or green color. Thus the best relative humidity is 65 to 70 percent. This need not be maintained constantly, but each day's curing conditions should average near this value. At ordinary temperatures, a rise of 20° F changes the relative humidity of a saturated atmosphere to about 50 percent. In other words, the water-holding capacity of the air is doubled by a rise of 20° F. This explains why use of heat in a barn prevents too high relative humidity.

With these facts in mind the principles involved in preventing houseburn and too dark a color in the cured leaf are more readily understood. The tobacco should be wilted as much as is practicable before being put into the barn. It should then be kept at a temperature between 60° and 90° F, and at a relative humidity averaging about 65 to 70 percent. The relative humidity may be determined by the feel of the tobacco. At a relative humidity of 55 to 60 percent at normal temperature, tobacco is dry to brittle, at 65 to 70 it is dry to low case, at 75 to 80 percent it is low to medium case, and at 85 to 90 percent it is medium to high case. The conditions in various parts of the barn can quickly be determined if the barn is equipped with a series of ropes hung from screw-eyes or pulleys from the top of the barn and extending to the floor. A series of 3 or 5 across the barn may be sufficient. A few cured flyings are wrapped in a piece of tobacco cotton 12 inches long by 6 inches wide. Several samples are tied to each rope so that one comes at each tier level. A knot in the rope at the floor indicates that the samples are in proper position. The barn can be quickly surveyed by pulling each sample down and feeling it.

After the tobacco is cured, it should be bulked down as soon as it can be brought sufficiently into case for handling, and stripped, graded, and again bulked as soon as possible. It should be remembered that each time the tobacco becomes damp, either during or after curing, the color is darkened and there is danger of houseburn.

In curing fire-cured tobacco the same principles apply, but the premium price is obtained for darker color, and the activity of the microbes is reduced by the wood smoke deposit on the leaves; consequently a higher relative humidity, probably about 80 to 85 percent should be used. The tobacco should hang in the barn for 3 or 4 days to bring about yellowing. This may be hastened about the fourth day by slow fires which raise the temperature to about 85° to 90° F, if the proper humidity can be maintained.

Slow, very smoky fires impart the desired smoky aroma to the tobacco. When the cure is completed, slow fires should be built during periods of high humidity.

RECOMMENDATIONS FOR CONTROL OF TOBACCO DISEASES IN KENTUCKY

Every tobacco grower should try to reduce the chances of crop failure as much as possible. There are numerous diseases of tobacco, some of which can be prevented completely by the right management of the crop. It is not always easy, of course, for a grower to become familiar with the details of each of the many diseases that attack tobacco and with the methods of prevention recommended for each. By closely following the summary of recommendations given here for control of tobacco diseases, however, a grower should be able to protect his crop against all diseases for which control methods are known, without requiring a detailed knowledge of any one of them.

Seed

Plant seed of a satisfactory variety resistant to black root-rot, mosaic, and other diseases, if possible, and plant no other kind until a better variety has been found and has definitely proved itself to be better. If mosaic has caused losses, there are satisfactory varieties available that are resistant to it. In fields where fusarium wilt has caused losses to burley tobacco in the past a fusarium wilt-resistant variety should be used. Burley varieties combining resistance to black root-rot, mosaic, wildfire, and fusarium wilt are now available.

Plant Beds

In former editions of this publication, it was recommended that a new plant-bed site be used each year. However, growers who are equipped to steam or gas treat beds in the fall have had success with control of the common bed diseases if the beds are steamed or gassed thoroughly. If beds are sowed to soybeans, or some other fast growing annual, as soon as setting is complete and plowed and treated in the fall, they are not likely to be affected with wildfire the next spring provided they are well ditched so no surface water flows across the bed.

The blue-mold fungus is carried from one year to another in burned beds but it is not proving to be a serious disease except once in about 6 or 8 years. A bed should not be located where there are many plantains or ribgrass, groundcherries, or horsenettle because of

the danger of mosaic. Beds should be so located that it is not necessary to go through the barn lot or across a field that previously had black shank in order to reach it. Never use ground tobacco stalks or other tobacco material unless sterilized or from a mosaic-resistant crop on the bed as a fertilizer, because it is nearly certain to introduce mosaic. Commercial fertilizers are safe and are as effective as tobacco materials.

Serious injury occurs to small seedlings during dry periods. It seems to be particularly severe in burned beds, and the hotter the ground is made the greater injury to the plants. In the past it has been thought that the injury to the roots just below the crown, with subsequent yellowing of the leaves, was caused simply by a concentration of fertilizer salts. There is evidence¹⁹ that extra heavy burning in spots in the bed may release quantities of manganese sufficient to be toxic to the young plants. There is also some evidence that the use of the same bed, burned each year, may result in an accumulation of manganese that is toxic not only to small seedlings but to those nearly ready to set. This suggests that it may be well to change the bed site frequently if only burning is used for weed control, and to give attention while burning not to burn too heavily in spots. Heavy watering, if started when plants just begin to yellow, sometimes prevents chemical injury. In watering beds use water that is free from all possibility of contamination by the black shank fungus.

To produce stalky plants sow a level teaspoon of seed on 35 to 45 feet of bed 12-feet wide. Sufficient bed space should be provided so that beds need not be pulled over more than twice. Repeated pulling spreads mosaic in susceptible varieties. When the plants are established in the bed and again 10 days later, sprinkle the bed with 3-4-50 bordeaux mixture (bluestone-lime) at the rate of 1 quart per square yard or 50 gallons to a bed 12 feet wide by 150 feet long or 9 feet wide by 200 feet long. Heavier applications are not injurious. The two applications should be completed before the plants are the size of a dime. Another application should be made immediately following weeding if this is done after the second application. This helps to prevent the bacterial diseases, angular leaf-spot and wildfire from developing in the bed. As a further precaution, ditch around the bed to keep surface water from flowing over it. The grower should have a good sprayer or duster on hand in case blue mold develops in the neighborhood. Application of ferbam or zineb should be made twice a week and after every rain, beginning as soon as the disease is reported in the neighborhood.

¹⁹ Studies by W. O. Atkinson, Ky. Exp. Sta. Annual Report for 1954.

Chewing and Smoking While Handling Plants

It has been clearly demonstrated in Kentucky that cured tobacco is the source of most of the mosaic infection of tobacco plants before and during transplanting. Therefore, do not use natural-leaf tobacco for either chewing or smoking and do not carry it or otherwise handle it while working around the plant bed. If natural-leaf tobacco has been handled recently, scrub the hands thoroughly with soap and water before handling plants in the bed. If natural-leaf tobacco has been carried in the pockets, brush them out, after which plug or twist tobacco may be substituted. Commerical plug, twist, and scrap chewing tobacco usually are free from mosaic and are much safer to use while working with the plants than natural-leaf tobacco. Pipe smokers who work with tobacco plants should use a brand of manufactured smoking tobacco rather than the natural-leaf. Manufactured cigarettes probably are safe to use while working with the plants. It is preferable, however, to use no tobacco whatever when working in the plant bed. Growers who wish to chew or smoke natural-leaf tobacco during the plant-bed and setting seasons should raise a mosaic resistant variety of tobacco for the whole crop or at least enough to make up a supply of mosaic-free chewing tobacco. A concentrated solution of trisodium phosphate destroys mosaic on the hands immediately. If a bucket of solution is kept at the bed during weeding and pulling and the hands dipped in it occasionally and setters do the same, mosaic can be largely prevented even when help is used who chew natural-leaf tobacco. Milk will also prevent infection from the hands if they are dipped in it before handling plants.

Field Practices

Do not set plants from a bed known to be affected with black root-rot unless the field soil is known to be distinctly acid. Do not set plants from a neighbor's bed unless it is known positively that it is a mosaic-resistant variety or that no barn-cured tobacco has been used by workmen while weeding or pulling plants and that there is no black shank on the farm. Soil high in organic matter, liberal applications of high-grade fertilizer, and liberal applications of manure all tend to reduce the injury from the bacterial leaf spot diseases. They also reduce firing and increase yield and quality, especially in dry seasons.

The few mosaic plants found at first cultivation or at any time when the plants are small should be removed from the field, preferably ahead of cultivation. If this is done by hand, healthy plants should not be touched until the hands have been washed with soap and water. If mosaic plants are found in burley fields at topping

time, they may be left untouched until cutting time, or topping may be delayed until most of the plants are in bloom, when all may be topped together without injury to the crop. Mosaic causes more injury to dark tobacco when spread at topping time than to burley because dark tobacco is topped earlier than burley. Consequently, efforts should be made to have the field free from mosaic at topping time. If mosaic plants are found they should be passed without touching and topped last. If black shank appears in a field the field should preferably be put in grass and all tools cleaned thoroughly before they are used to work in the new field.

Hornworms should be controlled by dusting or spraying rather than by hand worming. Handling the plants may spread mosaic, especially when the plants are wet.

Curing

To produce well-cured leaf and to prevent houseburn in burley tobacco keep the relative humidity between 65 and 70 percent. Relative humidity above 85 percent is almost sure to darken tobacco and reduce its value, while long exposure to such high humidity may cause houseburn. Every barn should be equipped with ropes, hung from rafters, on which cured samples of tobacco wrapped in tobacco cotton are tied. By pulling these down and feeling them the condition of the tobacco in any part of the barn can quickly be determined.